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JOURNAL of PALEONTOLOGY

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JOURNAL OF PALEONTOLOGY, VOL. 7, NO. 3, PP. 231–260, PLS. 28–30, SEPTEMBER, 1933

DIMORPHISM AND ORIENTATION IN OSTRACODES OF THE FAMILY KLOEDENELLIDAE FROM THE SILURIAN OF PENNSYLVANIA[1]

FRANK McKIM SWARTZ[2]

ABSTRACT

Dimorphism between specimens with a prominent postero-dorsal inflation, and specimens without this inflation, is recognized in *Dizygopleura hymenifera* n. sp. and other Kloedenellidae from the Middle Silurian Rochester and McKenzie formations of central Pennsylvania. The inflations are believed to represent female incubatory chambers. In several cases the females have hitherto been separated from the males and described as distinct species. Five new species are described, and eight species are redescribed, each with its dimorph.

The dimorphism of the Kloedenellidae provides valuable data on orientation, and the orientation of these and other Paleozoic ostracodes is discussed. The inflations of the Kloedenellidae are post-dorsal in position, while those of the true Beyrichiacea are post-ventral. This fact, and the characters of the hinge and outline, indicate that the Kloedenellidae should be removed from the superfamily Beyrichiacea, although they probably do not belong to the Cytheracea, the only other recognized superfamily to which they show relationship. The generic features of *Dizygopleura* are redescribed, and it is shown that *Dizygopleura* is not synonymous with *Poloniella*, as has been believed by Van Veen and Bonnema. Several species are removed from *Dizygopleura*.

INTRODUCTION

The work of Ulrich and Bassler[3] has shown the great value of ostracodes in stratigraphic studies of the Silurian deposits of the Appalachian province. Accordingly, particular attention has been given these fossils in the writer's work on the Silurian of central Pennsylvania.

Ostracodes of the family Kloedenellidae are exceptionally abundant and varied in the Middle Silurian Rochester and McKenzie formations of the above region, and form a considerable number of zones of much stratigraphic value over large areas. It now appears that the multiplicity of different kinds is due not only to specific but also to sexual differences. When this is recognized and expected, work with these fossils is considerably simplified and expedited. The dimorphism of the Kloedenellidae presents new data concerning their orientation and relationships.

DIMORPHISM IN DIZYGOPLEURA HYMENIFERA

In the Rochester-McKenzie Kloedenellidae dimorphism is particularly marked, and was first recognized in the new species *Dizygopleura hymen-*

[1] Published by permission of the Director, Pennsylvania Topographic and Geologic Survey.

[2] State College, Pa.

[3] *Maryland Geol. Survey*, Silurian, pp. 322–391, 500–704, 1923.

ifera, described in this paper. This species occurs in abundance a little below the top of the McKenzie formation near Williamsport and Danville. The specimens representing it comprise two groups. In the first group (pl. 28, figs. 1*a-e*), the surface of the valve is strongly quadrilobate, with narrow ridges and broad sulci. The outer ridge of the thicker end of the carapace, here described as the posterior ridge, is narrow, sharply defined on its outer as well as on its inner side, and is set some distance from the adjacent margin. In the second group (pl. 28, figs. 2*a-d*), the corresponding ridge is nearly obliterated by a strong inflation, which extends from the ridge to the adjacent margin, and causes some change in the outline of the end of the valve. The ends of the ridge remain, however, and define the ventral and dorsal ends of the neighboring sulcus, as in the first group of specimens. Since the two groups share very distinctive features, such as the peculiar long, wide, and flat-bottomed anterior sulcus, and since their stratigraphic and geographic ranges appear to be identical, it seems clear to the writer that they belong to one and the same species. This conclusion is greatly strengthened by the fact that similar relationships are found in many other McKenzie Kloedenellidae. It further seems probable that the inflations were female incubatory chambers, comparable to the brood pouches of the Paleozoic Beyrichiidae and Zygobolbidae, and to the incubatory chambers of some modern ostracodes.

DIMORPHISM IN OTHER KLOEDENELLIDAE

Paired groups of specimens, like those representing *Dizygopleura hymenifera*, and belonging to the genera *Dizygopleura*, *Kloedenella*, and *Eukloedenella*, occur at numerous horizons in the McKenzie and Rochester formations. As shown by the lobation, and the position of the hinge processes, the inflations when present always occur at the end in which they are found in the females of *D. hymenifera*. In each case, the two groups of specimens appear to have identical stratigraphic and geographic ranges. Furthermore, this condition is not found in one or two isolated species, but occurs in most, if not all, of the Kloedenellidae so far studied by the writer.

In many species the inflation is a conspicuous feature, and in some instances the two types of specimens have been separated and described as distinct species. This has made it appear that the genera in question are more diversified in character and much less stable than is actually the case. Using the orientation here adopted, the posterior end of the valve is strongly inflated in *D. acuminata* Ulrich and Bassler, of the uppermost part of the McKenzie of Maryland. Except for this inflation and the consequent prominence of the post-dorsal angle, *D. acuminata* agrees closely with the associated genotype, *D. swartzi* Ulrich and Bassler, and it is believed that the former is the female of the latter. An early variety of *D. swartzi*, represented by an abundance of both

males and females, occurs in Pennsylvania in beds corresponding to the middle part of the McKenzie of Maryland, and is illustrated in this paper (pl. 28, figs. 3*a-g*, 4*a-g*). In the Pennsylvania material, at least, the similarity of the two forms in size, hingement, fine reticulation of the surface, narrowness and length of the anterior sulcus, size of the median sulcus, and in other features of the lobation, is very marked.

Using evidence of the kind outlined in the above examples, the writer believes he has established dimorphism between specimens with a more or less well defined posterior inflation, and specimens without this inflation, in the following species:

With the exception of *Dizygopleura gibba* and *Kloedenella gibberosa*, all of the above species are described and figured in this paper.

Judging from published descriptions, dimorphism occurs in several additional species. Among species from the McKenzie of Maryland, *Eukloedenella umbonata* Ulrich and Bassler appears to be the female of the associated *E. indivisa* Ulrich and Bassler, while *Dizygopleura carinata* Ulrich and Bassler, *D. acuminata* var. *prolapsa* Ulrich and Bassler, and *D. bulbifrons* Ulrich and Bassler are evidently females, as is *D. affinis* Ulrich and Bassler of the Wills Creek shale. As illustrated by Ulrich and Bassler, *D. clarkei* (Jones) of the Manlius

DIMORPHISM OF SILURIAN KLOEDENELLIDAE

Name of species	Geologic horizon	Dimorph, where previously separated
Dizygopleura hymenifera F. M. Swartz n. sp.	Middle McKenzie	
Dizygopleura swartzi Ulrich and Bassler	Upper and middle McKenzie	*Dizygopleura acuminata* Ulrich and Bassler
Dizygopleura symmetrica (Hall)	Rochester	
Dizygopleura perrugosa Ulrich and Bassler	Upper McKenzie	
Dizygopleura gibba Ulrich and Bassler	Upper McKenzie	
Dizygopleura conjugata F. M. Swartz n. sp.	Lower McKenzie	
Dizygopleura brevisulcata F. M. Swartz n. sp.	Middle McKenzie	
Dizygopleura reticulata F. M. Swartz n. sp.	Lower McKenzie	
Kloedenella nitida Ulrich and Bassler	Middle McKenzie	
Kloedenella intermedia (*Dizygopleura intermedia* U. & B.)	Lower McKenzie	*Kloedenella scapha* Ulrich and Bassler
Kloedenella cornuta (*D. intermedia* var. *cornuta* U. & B.)	Basal McKenzie	*Dizygopleura proutyi* U. & B. part. and *Dizygopleura pricei* U. & B. part.
Kloedenella cornuta var. *praenuntia* F. M. Swartz n. var.	Upper Rochester	*Dizygopleura proutyi* U. & B. part. and *Dizygopleura pricei* U. & B. part.
Kloedenella gibberosa Ulrich and Bassler	Upper McKenzie	*Kloedenella subovata* Ulrich and Bassler
Eukloedenella sulcifrons Ulrich and Bassler	Lower McKenzie	*Eukloedenella longula* U. & B. and *Eukloedenella bulbosa* U. & B.
Eukloedenella sinuata U. & B. (*E. sinuata* var. *angulata* U. & B.)	Upper McKenzie	*Eukloedenella sinuata* Ulrich and Bassler

limestone of New York appears to be the female of *D. halli* (Jones) of the same formation.

DIMORPHISM IN DIZYGOPLEURA HIEROGLYPHICA

The above conclusions support the view of Van Veen[4] and Bonnema[5] that the posteriorly thickened specimens of *Dizygopleura hieroglyphica* (Krause) represent females, and the thinner specimens males. Judging from their figures and discussion, the females do not have a prominent or well defined inflation, but the posterior region is thickened without distinct modification of the lobation. Thus they have attributed the thickening of the posterior region to the greater development of the genitalia in the females, rather than to the presence of distinct incubatory chambers. Accordingly, one is not led by analogy to suspect that the prominent inflations of *D. "acuminata"* and *D. "proutyi"* are other than specific features.

COMPARISON WITH DIMORPHISM IN OTHER PALEOZOIC OSTRACODES

Dimorphism occurs, and has long been recognized, in various other Paleozoic ostracodes.[6] Thus species of *Beyrichia* and *Kloedenia*, and various other genera of the families Beyrichiidae and Zygobolbidae, are represented in part by specimens that have a distinct inflation or pouch in the post-ventral part of the valve, and in part by specimens without the pouch (see fig. 1). It has been generally accepted that the pouched valves represent females, and that the pouch was used to house eggs or possibly larvae. Although the inflations of the Kloedenellidae are post-dorsal and not post-ventral in position, it is suggested that they too are ovarian structures, similar in function to the previously recognized pouches. It is interesting to note that Blake,[7] in criticising the view that the post-ventral pouches of the Beyrichiacea were used to house "broods of young," states that the incubatory chambers found in the females of certain modern ostracodes are post-dorsal in position. He accordingly suggests that this is the part of the carapace in which ovarian structures might be expected in fossil ostracodes. Geis[8] has recently shown that at least one Mississippian species of *Glyptopleura*, and perhaps one species of *Savagella*, exhibit a dimorphism more or less comparable to that of the Kloedenellidae. In these, some specimens are thicker than the others in the post-dorsal region, and these are believed to represent females. The inflations are never well defined.

ORIENTATION OF THE CARAPACE IN THE KLOEDENELLIDAE

Recognition of the dimorphism of

[4] *Koninklijke Akademie van Wettenschappen te Amsterdam*, vol. 23, p. 994, 1921.

[5] *Jour. Paleontology*, vol. 4, no. 2, p. 111, 1930.

[6] In 1869 R. Richter compared the pouch in several European species of *Beyrichia* with the posterior swellings of the female of the Recent *Cythere gibba* Mull., *Zeits. d. deutsch. Geol. Gesell.*, vol. 21, p. 774, 1869. Also see Ulrich and Bassler, *Maryland Geol. Survey*, Silurian, pp. 277, 278, and text figs. 16–20, pp. 303–310, 1923.

[7] *Jour. Paleontology*, vol. 4, no. 3, p. 298, 1930.

[8] *Jour. Paleontology*, vol. 6, no. 2, pp. 151, 152, etc., 1932.

the Rochester-McKenzie Kloedenellidae was delayed, not only because the inflation when present changes the aspect of the one end of the valve, but also because the orientation used by Ulrich and Bassler places the inflation at the anterior end of the carapace. The possibility that these inflations might be female pouches, more or less comparable to those of the Beyrichiidae and Zygobolbidae, was accordingly obscured. Furthermore, as has been remarked, the inflations of the Kloedenellidae are more dorsal in position than are those of the above groups.

The orientation of Paleozoic ostracodes, and the evaluation of the various criteria upon which orientation has been based, have been the subjects of much uncertainty and discussion. During the last century, T. R. Jones and other workers generally followed the rule that the thicker end of the carapace is posterior, because this is generally true of modern ostracodes. Ulrich and Bassler have felt that this rule is useful, but not always reliable. Arguing from *Leperditia*, which is oriented by the small tubercles believed to represent the lateral eyes of modern ostracodes, they have concluded[9,10] that the carapaces of Paleozoic ostracodes typically extend farther behind than in front of the hinge extremities, so that the outline of the carapace typically has a backward swing. Passing from *Leperditia*, they have found that a large proportion of the Beyrichiacea have a similar swing to the outline, with the greater extension beyond the hinge in the direction of the swing, and they have oriented these ostracodes so that the swing is posterior in direction. Having thus oriented many of the Beyrichiacea, they have found it possible to check their conclusions, and to apply them to other members of the group, by comparison and correlation of the lobes and sulci of the various forms. In this manner they have reached the following conclusions. The median sulcus is generally somewhat post-median in position; when extended ventrally it tends to have a backward swing at its lower end; it is the widest and most persistent of the sulci. The next most persistent sulcus is that designated by them the posterior sulcus, although another, their anterior sulcus, may be present without the posterior one. There is a tendency to develop a small but elevated and persistent node behind the sulcus, as the carapace is held by them, and they call this the median lobe. They have found that the orientations established by these principles place the recognized brood pouches in their proper posterior position, and feel that even when the backward swing of the carapace is lacking, and a brood pouch absent, the correct orientation can be obtained from the relative positions of the median and posterior sulci and the median lobe.

Not recognizing the occurrence of brood inflations in the Silurian Kloedenellidae, Ulrich and Bassler oriented them by the lobation and outline, placing the persistent median

[9] *U. S. Nat. Mus. Proc.*, vol. 35, pp. 280–282, 1908.

[10] *Maryland Geol. Survey*, Silurian, pp. 283–285, 1923.

sulcus behind the middle, the more persistent of the secondary sulci in the posterior position, and the somewhat greater extension of the outline behind the hinge. The writer feels, however, that the evidence afforded by the brood inflations, as here recognized, outweights the above interpretation of the lobation, and hence that the end with the inflation must be considered posterior. This orientation places the greatest thickness of the carapace behind the middle.

It should further be noted that the true Kloedenellidae are so distinct in character from the Beyrichiacea as hereinafter emended, that the rules of lobation and outline valid to the one group do not necessarily apply to the other. Besides the important difference in the position of the brood pouch, the former group has an oblong rhomboidal outline, with a single prominent cardinal angle, and a straight or even sinuate ventral margin, instead of the dorsally truncated elliptical outline and two prominent cardinal angles of the Beyrichiacea.

Geis[11] has recently described some Mississippian ostracodes with an elongate rhomboidal outline much like that of the Silurian Kloedenellidae. He compares these with certain modern ostracodes of similar shape, and shows that in the latter the prominent cardinal angle is posterior, and the distinct swing of the carapace is anterior and not posterior in direction.

Geis also reëmphasizes the fact that in modern ostracodes having one end thicker than the other, the thicker end is generally posterior, and that consequently the thicker end should be posterior in fossil ostracodes. The writer agrees with this view, but does not accept the accompanying argument that the thicker end must always have been posterior because the reverse orientation would offer too much resistance to movement through the water. In the first place, when the habit of swift movement necessitates the reduction of the resistance of a body to movement through a fluid, the posterior taper seems to be as important as the anterior taper, and there is a tendency to place the greatest thickness well forward. This principle is well illustrated by the shapes of fish and marine mammals, as well as by the stream lining of airplane parts. In the second place, the bizarre ornamentation and frills so frequently developed in Paleozoic ostracodes indicate that the need of reducing resistance to movement through the water was not a dominant evolutionary factor in the group.

ORIENTATION OF THE BEYRICHIACEA

In the Paleozoic Beyrichiacea as a whole, the writer agrees with Kummerow[12] that the position of the brood pouch, when such is present, affords the most valuable of the known means of orienting the carapace, and that the other criteria will have to be adapted accordingly. Although the use of the pouch in this long extinct group, and its relation to the soft parts, can not be estab-

[11] *Jour. Paleontology*, vol. 6, no. 2, pp. 150, 151, etc., 1932.

[12] *Jour. Paleontology*, vol. 5, no. 2, pp. 155–159, 1931.

lished by direct evidence, the stratigraphic and evolutionary data clearly show that the pouched individuals are conspecific with associated non-pouched individuals; while with present knowledge the only plausible explanation of such pouches is that they were ovarian structures, and accordingly should be posterior in position.

In a recent paper, Bonnema[13] accepts the ovarian character of the pouches of the Beyrichiacea, but considers them antero-ventral and not post-ventral in position. He bases this view chiefly on his belief that the adductor muscle, as shown by modern ostracodes, by *Leperditia*, and by *Primitia tolli* when oriented by what he believes are eyespots, is either median or antero-median in position, and rarely if ever post-median. He further believes, largely from his investigation of *P. tolli*, that the median sulcus of the Beyrichiacea represents the place where the adductor muscle was attached on the interior of the valve. Hence he concludes that the median sulcus is median or antero-median in position, and not median or post-median as believed by Ulrich and Bassler. Bonnema also finds that in modern and Cretaceous ostracodes, and in Paleozoic ostracodes as oriented by him, the left valve overlaps the right along the free margins, the sharp free edge of the right valve generally resting in a furrow in the thickened edge of the left valve.

Using the supposed anterior position of the median sulcus and the manner of overlap as his prime factors, Bonnema orients the carapace of *Beyrichia* and other Beyrichiacea so that the pouches are antero-ventral in position. In support of this view, Bonnema cites certain modern ostracodes in which the testes of the male run the entire length of the ventral part of the body, and suggests that this should also be true of the female ovaries. Therefore, he believes, it would be quite feasible to have the pouch in the antero-ventral part of the carapace. If the pouch was used as an incubatory chamber for eggs, its position should have been controlled, not by the position of the ovaries, but rather by the position of the genital ducts. Furthermore, when eggs are housed in the carapace of the female of modern ostracodes, they are placed in the posterior end. The arguments for the posterior position of the pouch seem to the writer decisive.

It is most interesting that whereas Bonnema's orientations place the pouches in the anterior part of the carapace in the Beyrichiacea, the Silurian Kloedenellidae are so oriented that the inflations here described are made posterior. Although based largely on his theses that the median sulcus is fundamentally antero-median in the Beyrichiacea, and that the left valve always overlaps the right —views that the writer does not accept—Bonnema also supports his orientation of the Kloedenellidae, and indeed his conclusion as to the position of the median sulcus, by the dimorphism of *Dizygopleura hieroglyphica*.

[13] *Jour. Paleontology*, vol. 4, no. 2, pp. 109–120, 1930.

CLASSIFICATION OF THE KLOEDENELLIDAE

In addition to the Silurian genera *Dizygopleura*, *Kloedenella*, and *Eukloedennella*, Ulrich and Bassler[14] have included in their family Kloedenellidae the Carboniferous genera *Kirkbyina* Ulrich and Bassler, *Jonesina* Ulrich and Bassler, *Beyrichiopsis* Jones and Kirkby, and *Beyrichiella* Jones and Kirkby, and Geis[15] has recently added his Mississippian genus *Oliganisus*. The writer is not prepared to fully discuss the relationships of the Carboniferous genera. Judging from the literature, however, *Oliganisus* is the only one of the above genera that exhibits a well marked oblong rhomboidal outline comparable to that of the Silurian genera. The other genera will require further study, particularly with respect to their possible dimorphism, before their relationships to the Kloedenellidae can be determined.[16]

As shown by Geis, the Carboniferous genera *Glyptopleura* Girty and *Savagella* Geis, of the family Glyptopleuridae Girty, both exhibit an oblong rhomboidal outline similar to that of the Kloedenellidae, and apparently have females in which the post-dorsal region is definitely thickened. This family appears to be closely related to the Kloedenellidae. *Oliganisus* might well be placed in this family, as it lacks the anterior hinge-tooth characteristic of most of the Silurian Kloedenellidae, is not strongly sulcated, and the inflation of the female is not well defined.

The fundamental differences between the Silurian Kloedenellidae and the true Beyrichiacea have already been mentioned. The Kloedenellidae (see Fig. 1) are characterized by (1), the oblong rhomboidal outline, with a prominent posterior cardinal angle, no distinct anterior cardinal angle, comparatively full antero-ventral region, and the straight or even sinuate ventral margin, and, (2), the post-dorsal position of the brood inflation. The true Beyrichiacea, on the other hand, have (1), a dorsally truncated subelliptical outline, with the hinge angulated at both ends, and with the ventral margin more or less convex in outline, and not sinuate as it tends to be in the Kloedenellidae, and, (2), the brood pouches when present are post-ventral in position. It seems to the writer that these differences are so important that the Kloedenellidae must be removed from the Beyrichiacea, along with the Glyptopleuridae. As the group is expanded by further work, it may be desirable

[14] *Maryland Geol. Survey*, Silurian, pp. 312–314, 1923.

[15] *Jour. Paleontology*, vol. 6, no. 2, pp. 158, 159, 1932.

[16] The Upper Pennsylvanian and Permian species of *Jonesina* recently described by Kellet (*Jour. of Pal.*, vol. 7, no. 1, pp. 76–82, pl. 14, figs. 1–8, 13–27, 32–36, 43–45, March, 1933) are very closely related to the Silurian Kloedenellidae. Thus they are more or less elongate rhomboidal in outline, with recessive antero-dorsal angle (post-dorsal angle in Kellet's description); they have flattened areas or shoulders bordering the hinge (see particularly figs. 2 and 4) of the type seen in the Silurian forms; and as Kellet shows they are dimorphic, the females bearing a strong postero-dorsal swelling (antero-dorsal according to Kellet) corresponding closely in character and position to the swellings of the females of the Silurian genera. The hinge is more or less denticulate. The one valve overlaps the other along the free edge, but the right valve overlaps the left in *Jonesina*, while the left overlaps the right in the Silurian Kloedenellidae."

to erect it as a separate superfamily. However, its relations to the Cytheracea will need further investigation. The oblong rhomboidal outline, and the post-dorsal position of the outline, incubatory chambers, when present, post-ventral in position. As so defined, it includes the families Primitiidae Ulrich and Bassler, Zygobolbidae Ulrich and Bassler, and

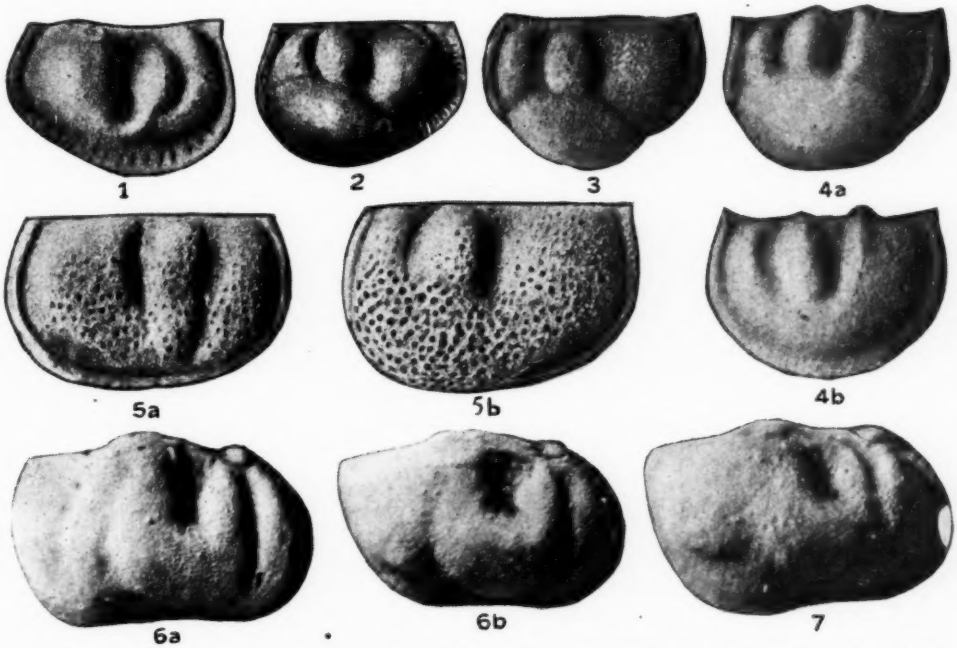

FIG. 1—Comparison of outline and brood pouches of typical Beyrichiacea (1–5) and Kloedenelliade (6, 7). 1, male left valve of *Beyrichia lakemontensis* Ulrich and Bassler, ×14; 2, female right valve of *Beyrichia hartnageli* Ulrich and Bassler, ×17½; the brood pouch of this species is not as globular as is typical of the genus; 3, female right valve of *Kloedenia normalis* Ulrich and Bassler, ×17½. 4*a*, *b*, female and male right valves of *Kyammodes tricornis* Ulrich and Bassler, ×14; 5*a*, *b*, male left and female right valves of *Zygobeyrichia ventripunctata* Ulrich and Bassler, ×10½; in the latter the brood pouch is an undefined post-ventral swelling; 6*a*, *b*, male and female right valves of *Dizygopleura swartzi* Ulrich and Bassler, ×27, the latter showing the post-dorsal inflation characteristic of female *Kloedenellidae;* 7, female right valve of *Kloedenella nitida* Ulrich and Bassler. All the above species are Silurian. 1–5 after Ulrich and Bassler.

female inflations or thickenings, are suggestive of certain members of the Cytheracea.

With the above groups removed, the superfamily Beyrichiacea comprises sulcated ostracodes, with straight, doubly angulated hinge, dorsally truncated elliptical outline, ventral margin more or less convex in Beyrichiidae Jones, emend. Ulrich and Bassler.[17]

The family Kirkbyidae Ulrich and Bassler[18] has also been included in the Beyrichiacea. As suggested by its authors, this family is probably

[17] See *Maryland Geol. Survey*, Silurian, pp. 297–312, text figs. 15–20, 1923.

[18] *Maryland Geol. Survey*, Silurian, pp. 315, 316, text fig. 22, 1923.

an unnatural association of genera, in part trending toward the Cytheracea. The genera are non-sulcate, although *Kirkbya* and *Amphissites* have subcentral pits, and are not known to have brood pouches. The interlocking processes at each end of the hinge in *Amphissites* Girty, as shown by Roth,[19] are somewhat suggestive of those of *Cythere* Müller and *Cythereis* Jones, both of the Cytheracea. The Kirkbyidae probably should be removed from the Beyrichiacea, but for the present their classification is uncertain.

NON-EQUIVALENCE OF DIZYGOPLEURA AND POLONIELLA

Van Veen[20] has suggested that *Kloedenella* Ulrich and Bassler, and more particularly species which Ulrich and Bassler subsequently placed in their genus *Dizygopleura*, belong in *Poloniella* Gurich. The argument is that the Middle Devonian genotype, *P. devonica*, and the Silurian *Dizygopleura hieroglyphica*, have hinge teeth in the anterior part of the cardinal margin of the left valve, and that the lobation is essentially similar, consisting in each case of three vertical sulci, the middle sulcus shorter than the outer ones. Bonnema[21] has accepted this view, and Kummerow[22] agrees that *D. hieroglyphica* belongs in *Poloniella*, although he apparently believes that *Kloedenella* and *Dizygopleura* are otherwise distinct from *Poloniella*.

It seems to the writer that the work of Ulrich and Bassler has shown that both *Kloedenella* and *Dizygopleura* are fairly large groups, quite distinct from *Poloniella*, and that Ulrich and Bassler may well be correct in suggesting that *Poloniella* is probably related to *Octonaria* of the family Thlipsuridae.[23] In the Silurian and Lower Devonian species of *Dizygopleura*, the outline is oblong rhomboidal in side view, with a rather long straight hinge, sharp posterior cardinal angle, rounded antero-dorsal bend, straight or sinuate ventral margin, and with a more or less distinct anterior "swing." The hinge is characterized, not only by the anterior tooth of the left valve (this tooth is sometimes obsolete), but also by the fact that it is bordered, at least in the left valve, by a flattened or even concave area. This area is widest about one-third in front of the rear end, so that it is more or less triangular in shape from the dorsal view. Its outer margin is angulated and forms a distinct dorsal shoulder. In the right valve the corresponding angulation is generally more elevated, and frequently forms a strong crest, more or less obliterating the flattened area in this valve. The anterior sulcus of the left valve is frequently extended dorsally onto the hinge tooth, so that this tooth may be regarded as a linguiform extension from the sulcus. The surface of the valve is strongly quadrilobate. The

[19] *Wagner Free Inst. Sci., Publ.*, vol. 1, p. 33, pl. 3, figs. 14*b*, 16*b*, 1929.

[20] *Koninklijke Akademie van Wettenschappen te Amsterdam*, vol. 23, pp. 993–996, 1921.

[21] *Jour. Paleontology*, vol. 4, no. 2, p. 111, 1930.

[22] *Jour. Paleontology*, vol. 5, no. 2, p. 158, 1931.

[23] *Maryland Geol. Survey*, Silurian, p. 664, 1923.

median sulcus is comparatively stable, more or less rectangular in outline, subvertical, rarely extending as much as halfway from the dorsal to the ventral margin of the valve. The anterior lobe or ridge lies fairly close to the anterior margin; the posterior ridge is generally narrow, and apparently is always set well in front of the anterior margin. The left valve overlaps the right along the free margin. *Kloedenella* agrees with *Dizygopleura* in the above respects, except that the posterior sulcus and posterior lobe are not developed. The anterior sulcus tends to be distinctly shorter than in *Dizygopleura*.

Dizygopleura hieroglyphica (pl. 29, fig. 1) apparently conforms to all of the above characters. In *Poloniella devonica* (pl. 29, figs. 11*a*, *b;* pl. 30, figs. 9*a*, *b*), on the contrary, the outline is more or less oval, the hinge is not conspicuous, and there is no distinct post-dorsal angle. The hinge is not bordered by the flattened areas and angulations seen in *Dizygopleura*, but judging from Van Veen's figures the left valve is enlarged along its dorsal margin, as though it overlaps on the right valve here as elsewhere. Furthermore, the hinge tooth of the left valve has no relationship to the anterior sulcus, as it generally has in *Dizygopleura*. The median sulcus is comparatively long, narrow, and oblique, and the anterior and posterior sulci are confluent ventrally. The posterior lobe is close to the posterior margin. It accordingly seems clear to the writer that *Dizygopleura* and *Kloedenella* are not synonymous with nor closely allied to *Poloniella*. Although *Poloniella* has an elliptical outline, rather than the reniform outline of the typical members of the Thlipsuridae, its lack of dorsal angles, and its suggestion of dorsal overlap of the one valve by the other, combined with the strongly sulcate surface, indicate that it should probably be placed in that family.

SPECIES TO BE REMOVED FROM DIZYGOPLEURA

Dizygopleura concentrica Ulrich and Bassler[24] has the doubly angulated hinge, convex ventral margin, and general aspect of *Kloedenia* and *Welleria* of the family Zygobolbidae. The low anterior ridge (which suggests the posterior ridge of *Dizygopleura* as here oriented) is not bordered by a sulcus such as that characteristic of *Dizygopleura*. The median lobe is not elevated as is typical of *Kloedenia*, and the anterior ridge is an unusual feature for either *Kloedenia* or *Welleria*. The species may be referred with question to *Welleria*, but the character of its brood pouch must be determined before it can be properly classified. The peculiar anterior ridge may make it desirable to separate this species as the type of a new genus. *D. concentrica* var. *subquadrata* Ulrich and Bassler[25] belongs in *Dizygopleura*, and is closely related to *D. brevisulcata* F. M. Swartz n. sp.

Dizygopleura landesi Roth[26] of the

[24] *Maryland Geol. Survey*, Silurian, p. 691, pl. 61, fig. 11, 1923.
[25] *Maryland Geol. Survey*, Silurian, p. 692, pl. 61, fig. 12, 1923.
[26] *Jour. Paleontology*, vol. 3, no. 4, pp. 341–344, pl. 35, figs. 7*a–i*, 1929.

Lower Devonian Haragan marl of Oklahoma has the oblong rhomboidal outline, straight hinge, prominent posterior cardinal angle, anterior hinge tooth, and other features characteristic of *Dizygopleura*. On the other hand, this is not true of the species Roth described as *D. recta* and *D. obliqua*,[27] with some question as to their generic relations. These are closely related species of oblong subreniform and not oblong rhomboidal outline. There is a suggestion of a short straight hinge line, but there are no distinct cardinal angles. There is no hinge tooth, and the hinge is not bordered by the flattened areas of *Dizygopleura*. They lack the median sulcus of the Kloedenellidae, and have a vertical crateriform depression at each end of the valve, surrounded by an elevated rim. The outline and other features show clearly that these species do not belong to the Kloedenellidae. Roth compared them with the Carboniferous *Phreatura concinna* Jones and Kirkby of the Thlipsuridae, which has similar terminal craters; but did not believe them related to the latter form, because its posterior end is strongly compressed, and it is strongly reniform in outline, with the dorsal margin broadly rounded. Nevertheless, the outline and other features of Roth's species are very close to those of *Phreatura*, and, in the writer's opinion, *D. recta* and *D. obliqua* should either be placed in *Phreatura* or erected as a closely related genus in the Thlipsuridae.

[27] *Jour. Paleontology*, vol. 3, no. 4, pp. 344–346, pl. 36, figs. 8*a–c*, 9*a*, *b*, 1929.

FORMATIONAL BOUNDARIES

In the following systematic descriptions, the occurrences of the various species are given in terms of the boundaries of the McKenzie formation. In south central Pennsylvania, the top of the McKenzie is about the same as in the type region in western Maryland; but as the McKenzie is followed northward a thick red bed is developed about 100 to 150 feet below its top, and between Mt. Union, Pa., and Lewistown, Pa., this red bed unites with the overlying Bloomsburg red shale. Thus in north central Pennsylvania, the true upper McKenzie has passed laterally into the basal part of the Bloomsburg.

The basal part of the McKenzie is more constant in character, but there has been some question as to where the boundary with the underlying Rochester shale should be drawn. As originally described by Stose and Ulrich,[28] the base of the McKenzie was placed at the base of the Keefer sandstone in the Hancock, Md., area. In the later work of C. K. Swartz and W. F. Prouty,[29] the Keefer is shown to be early Rochester in age, and the Rochester-McKenzie boundary is placed at the top of beds containing a profusion of *Whitfieldella marylandica*. The position of this contact was based primarily on the ostracode evidence as interpreted by Ulrich and Bassler. The writer's work indicates that the *W. marylandica* beds

[28] *U. S. Geol. Survey, Geol. Atlas of the U. S.*, folio 149, p. 6, 1912.

[29] *Maryland Geol. Survey*, Silurian, pp. 35–39, 53–104, 202–206, 1923; also see Ulrich and Bassler, *idem.*, pp. 245–247, 1923.

are more intimately related to the McKenzie than to the Rochester. For instance, *Drepanellina clarki*, *Camarotoechia neglecta*, and *Strophe-odonta* aff. *S. pleuristriata*, all of which are exceedingly profuse in the underlying beds, simultaneously disappear at the base of the *W. marylandica* zone, and this paleontological boundary is very sharp in all of the sections studied by the writer. The *W. marylandica* zone does not have a sharply defined top, and the ostracodes of its upper part are rather intimately related to those of the overlying beds. Accordingly, in the statements giving the occurrences of the various species, measurements "above the base of the McKenzie" are made from the top of the range of *Drepanellina clarki* and *Camarotoechia neglecta*.

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SYSTEMATIC DESCRIPTIONS

Family KLOEDENELLIDAE Ulrich and Bassler

Genus DIZYGOPLEURA Ulrich and Bassler

DIZYGOPLEURA HYMENIFERA F. M. Swartz, n. sp.

Plate 28, figures 1*a–e*, 2*a–d*

Male carapace subelliptical to subovoid in dorsal view, greatest thickness at the post-median and posterior lobes; subrectangular to subrhomboidal in side view, with rounded antero-dorsal bend, and sharp, though obtuse, post-dorsal angle; dorsal margin slightly humped in the right valve; anterior margin broadly rounded; ventral margin slightly convex; posterior margin most extended about one-third below the dorsal angle, somewhat recessive below. Only separated valves have been seen, but apparently the antero-dorsal hinge tooth and socket are obsolete or nearly so. Hinge bordered by flattened areas.

Surface of valve convex, strongly quadrilobate, at least in the specimens here considered typical. In other specimens, here left in the species, the lobation is weaker than in the figured valves. Lobes elevated, narrower than the sulci. Anterior lobe narrow, long, lying near to and paralleling the anterior margin; connected below with the antero-median lobe, but free dorsally. Slope to anterior margin concave. Antero-median lobe nearly straight, vertical, its dorsal free part narrow; the broad ventral tabular area connecting it with the post-median lobe sometimes with its summit scarcely depressed, so as to obscurely outline the lower ends of the antero- and post-median lobes, and form a scarcely discernible cross-bar just below the median sulcus. Posterior lobe narrow, crescentic, set a considerable distance from the posterior margin, joined to the post-median lobe both dorsally and ventrally. The surface is flattened above the dorsal confluence of these lobes,

EXPLANATION OF PLATE 28

FIGS. 1*a–e*—*Dizygopleura hymenifera* F. M. Swartz, n. sp., males, ×20. 1*a*, Side view of left valve. 1*b*, Ventral view of left valve. 1*c*, Side view of left valve. 1*d*, Dorsal view of left valve, hinge tooth absent or nearly so. 1*e*, Small right valve, posterior sulcus with coarse punctæ. From 12 to 15 feet below top of McKenzie formation, Reading railroad, 2.5 miles east of Montoursville, Pa.

2*a–d*—*Dizygopleura hymenifera* F. M. Swartz, n. sp., females, ×20. 2*a*, Side view of right valve. 2*b*, Ventral view of right valve. 2*c*, Dorsal view of right valve. 2*d*, Side view of left valve with slightly weaker lobation. From 12 to 15 feet below top of McKenzie formation, Reading railroad, 2.5 miles east of Montoursville, Pa.

3*a–g*—*Dizygopleura swartzi* Ulrich and Bassler, males, ×21. 3*a*, Right view of carapace showing fine surface punctae. 3*b*, Dorsal view of same specimen showing strong hinge tooth of left valve made by extension from anterior sulcus. 3*c*, Right view of carapace. 3*d*, Right view of another carapace showing slight difference in outline but essential constancy of lobation. 3*e*, Side view of left valve showing absence of dorsal crest. 3*f*, Ventral view of carapace. 3*g*, Posterior view of carapace. Specimen shown in 3*a*, *b* from about 125 feet above base of the McKenzie formation, quarry on road to McElhatten, 1.5 miles east of Castanea, Pa. Others from 50 to 51 feet below top (or about 125 feet above base) of the McKenzie formation, Reading railroad, 2.5 miles east of Montoursville, Pa.

4*a–g*—*Dizygopleura swartzi* Ulrich and Bassler, females, ×21. 4*a*, Right view of carapace with acuminate postdorsal angle. 4*b*, Dorsal view of same specimen. Compare Figs. 3*a*, *b* and 4*a*, *b* noting surface punctae, hinge tooth, and the median and posterior sulci. 4*c*, Side view of right valve with less acuminate postdorsal angle and suggestion of a broad posterior lobe. 4*d*, Side view of left valve. 4*e*, Dorsal view of carapace. 4*f*, Ventral view of carapace. 4*g*, Posterior view of carapace. Specimens shown in 4*a*, *b*, *f*, *g* from 50 to 51 feet below top (or about 125 feet above base) of the McKenzie formation, Reading railroad, 2.5 miles east of Montoursville, Pa. Others from about 125 feet above base of the McKenzie formation in quarry on road to McElhatten, 1.5 miles east of Castanea, Pa.

5*a–i*—*Dizygopleura symmetrica* (Hall), males, ×21. 5*a*, Side view of left valve. 5*b*, Ventral view of same. 5*c*, Dorsal view of same. Note that the anterior sulcus is long but closed ventrally and that the posterior sulcus is open ventrally but closed dorsally. Surface pitting due to weathering. 5*d*, Side view of right valve showing low dorsal crest. 5*e*, Dorsal view of left valve probably a little flattened by pressure. 5*f*, Side view of left valve. 5*g*, Ventral view of same. 5*h*, Dorsal view of same. 5*i*, Side view of right valve. Specimens shown in 5*a–e* from slab of Rochester shale, Niagara River gorge, east side; 5*f–h* from one foot below top of Rochester shale, Lakemont, near Altoona, Pa.; 5*i* from upper part of Rochester shale, ½ mile east of Castanea, Pa. Note flattening of summit of posterior lobe and lesser width of anterior sulcus in 5*f–h* as compared to 5*a–e*.

6*a–h*—*Dizygopleura symmetrica* (Hall), females, ×21. 6*a*, Side view of left valve. 6*b*, Ventral view of same. 6*c*, Dorsal view of same. 6*d*, Side view of right valve, surface pitting due to weathering. 6*e*, Side view of left valve. 6*f*, Ventral view of same. 6*g*, Dorsal view of same. 6*h*, Side view of left valve. Specimens shown in 6*a–d* from slab of Rochester shale, Niagara River gorge, east side; 6*e–g* from one foot below top of Rochester shale, Lakemont, near Altoona, Pa.; 6*h* from two feet above base of McKenzie formation, Route 103, 1.5 miles south of Lewistown, Pa.

7*a–c*—*Dizygopleura perrugosa* Ulrich and Bassler, male, ×21. 7*a*, Side view of small left valve. 7*b*, Dorsal view of same. 7*c*, Ventral view of same. Note that true dorsomedian sulcus extends only about halfway across the valve. From top of the *Kloedenella gibberosa* zone of the upper McKenzie formation, near Mount Union, Pa.

8*a–c*—*Dizygopleura perrugosa* Ulrich and Bassler, female, ×21. 8*a*, Side view of large right valve. 8*b*, Dorsal view of same. 8*c*, Ventral view of same. Note the dorsal crest of this valve and the extent of the true dorsomedian sulcus only about halfway across the valve. From top of the *Kloedenella gibberosa* zone of the upper McKenzie formation, near Mount Union, Pa.

Swartz, Silurian Ostracodes

forming the dorsal shoulder characteristic of the genus. Anterior sulcus long, very broad, of moderate depth, flat-bottomed. Median sulcus extending less than one-half the distance across the valve, its posterior margin about at the middle of the valve; a little wider dorsally than below, deeper than the other sulci. Posterior sulcus comparatively narrow, not very deep, its floor more or less flattened; frequently a little sinuate.

Females like males, except that the area between the posterior sulcus and the posterior margin is strongly inflated, obliterating the posterior lobe except at its ventral and dorsal ends. The inflation does not have a well defined ventral margin. Post-dorsal region somewhat more protuberant than in the males.

A large male left valve measures length 1.28 mm., height 0.70 mm., convexity 0.30 mm.; a large female left valve measures length 1.26 mm., height 0.74 mm., convexity 0.30 mm.

This species is a little suggestive of *Dizygopleura virginica* Ulrich and Bassler[30] of the Sneedsville limestone of northeastern Tennessee, which is figured with comparatively narrow lobes, and with the posterior lobe connected at both ends to the median lobe. However, the median sulcus appears to be distinctly longer, and the anterior sulcus narrower than in *D. hymenifera*. Furthermore, the cotypes of *D. virginica* are not exteriors, but natural internal casts, and the lobes would probably be thicker as seen on the exteriors.

[30] *Maryland Geol. Survey*, Silurian, p. 699, pl. 60, figs. 27–29, 1923.

Occurrence.—Abundant 12–15 feet, common 18–23 feet below top of the McKenzie formation, Reading R. R., about 2½ miles east of Montoursville, Pa.; some poor specimens near top of McKenzie, quarry 1½ miles east of Castanea, near Loch Haven, Pa.; and common 4 feet below top of McKenzie, State highway 3 miles west of Danville, Pa. In the above area, the McKenzie is about 175 feet thick, and corresponds to about the lower half of the typical McKenzie of western Maryland.

DIZYGOPLEURA SWARTZI Ulrich and Bassler

Plate 28, figures 3*a–g*, 4*a*–

Dizygopleura swartzi ULRICH and BASSLER, *1923*. Maryland Geol. Survey, Silurian, p. 693, pl. 62, figs. 1–8.

Dizygopleura acuminata ULRICH and BASSLER, *1923*, Maryland Geol. Survey, Silurian, p. 685, pl. 60, figs. 4–9.

Male carapace subelliptical in dorsal view, greatest thickness just in front of posterior sulci, lobes not conspicuous; oblong-rhomboidal in side view, the dorsal and ventral margins nearly parallel; ventral margin slightly sinuate, anterior margin broadly rounded, fullest a little below its middle, posterior margin more or less truncated, most extended in its upper part. Post-dorsal angle sharp, slightly obtuse in the males, more or less acute in the females; no true anterior cardinal angle, the anterior margin rounding gradually into the dorsal margin, except for the low hump of the hinge tooth. Right valve with a strong medio-dorsal crest, that is absent in the left valve; left valve with a broad dorsal shoulder, widest above the posterior sulcus. Left valve with a strong, extended antero-dorsal hinge tooth, ap-

parently made by a linguiform dorsal extension from the anterior sulcus; behind this tooth, the dorsal margin of the left valve is a little excavated, making room for the buttress behind the socket in the right valve. Left valve overlaps a little on the right along the free margins.

Anterior sulcus comparatively narrow, moderately deep, nearly straight, almost vertical, extending about three-quarters the distance across the valve, definitely terminated at its lower end. Median sulcus deep, extending about one-third the distance across the valve, subrectangular in shape. Posterior sulcus narrow, moderately deep, open ventrally, gradually terminated dorsally some distance below the dorsal margin, particularly in the crested right valve. Posterior lobe in males narrow, rather low, crescentic, set a considerable distance from the posterior margin. In the females the true posterior lobe is obliterated by a strong posterior inflation that extends from the posterior sulcus to the posterior margin. This inflation is well defined below, thus leaving a distinct post-ventral flange. In well preserved specimens, the surface is finely punctate.

A large male carapace measures length 1.30 mm., height with dorsal crest of right valve 0.81 mm., without this crest 0.75 mm., thickness 0.66 mm.

D. swartzi and *D. "acuminata"* were described by Ulrich and Bassler from the upper fifty feet of the McKenzie of western Maryland. The material here figured and referred to *D. swartzi* was obtained in central Pennsylvania from beds corresponding to the middle and not the upper part of the McKenzie of Maryland. This material has a slightly stronger crest than the type specimens, and the specimens here figured have a weaker posterior sulcus. Specimens from beds about 25 feet lower than the beds from which the figured specimens were obtained have a stronger posterior sulcus. At the present time the slight differences in the height of the right dorsal crest and the strength and length of the posterior sulcus do not seem adequate to separate the middle McKenzie material from the types, although this may prove possible with further study. The only specimens the writer has seen from the upper McKenzie are the cotypes at Washington. Beds with *D. swartzi* are not present in the upper McKenzie of Pennsylvania, at least north of Bedford, Pa.

Occurrence.—Material with the shallow posterior sulcus of the specimens here figured occurs as follows: abundant 50–51 feet below top, or about 125 feet above base of the McKenzie, Reading R. R., about 2½ miles east of Montoursville, Pa. (in north central Pennsylvania the upper half of the McKenzie of Maryland has passed laterally into the basal part of the Bloomsburg red shale); abundant about 125 feet above base of the McKenzie in quarry 1½ miles east of Castanea, near Loch Haven, Pa.; common about 100 and 145 feet above base of the McKenzie, highway 3 miles west of Danville, Pa.; common 85 feet above base of McKenzie, Lakemont, near Altoona, Pa.; common 80 and 95 feet above base of McKenzie along route 103, about 1½ miles south of Lewistown, Pa. Material with stronger posterior sulcus occurs at the above sections as follows: abundant 103–107 feet below top of McKenzie, Mon-

toursville; abundant about 105 feet above base of McKenzie, quarry near Castanea; abundant 52, 54, and 83 feet above base of McKenzie at Lakemont; common 70 and 100 feet above base of McKenzie at Danville; and common 61 and 80 feet above base of McKenzie, 1½ miles south of Lewistown.

DIZYGOPLEURA SYMMETRICA (Hall)

Plate 28, figures 5*a–i*, 6*a–h*

Beyrichia symmetrica HALL, *1852*, Paleontology, N. Y., vol. 2, p. 317, pl. 67, fig. 16.

Bollia symmetrica GRABAU, *1902*, Rept. N. Y. State Mus., vol. 54, pt. 4, p. 219, text fig. 151.

Dizygopleura symmetrica ULRICH and BASSLER, *1923*, Maryland Geol. Survey, Silurian, p. 695, pl. 62, figs. 13–17.

Carapace suboblong to subpentagonal in dorsal view, a little thicker posteriorly than in front; anterior hinge tooth of left valve broad, moderately long, marked by extension of the anterior sulcus; each valve with a moderately broad flattened dorsal shoulder, widest above the posterior sulcus; carapace subrectangular in side view, dorsal margin of right valve with a low post-median hump, dorsal margin of left valve straight except for low hump made by hinge tooth; anterior margin broadly rounded, ventral margin straight or slightly sinuate, posterior margin more or less truncated as compared to the anterior margin, a trifle recessive in its lower part; posterior cardinal angle obtuse but sharp.

Surface of valve strongly quadrilobate; anterior lobe crescentic, closely bordering the anterior margin, strongly elevated; anterior sulcus comparatively wide, deep, long, open dorsally but definitely terminated just above the ventral margin; median sulcus large, deep, extending nearly halfway across the valve; antero-median lobe narrower than the post-median lobe; posterior sulcus long, open below, terminated above, slightly narrower than the anterior sulcus; posterior lobe elevated, moderately thick, its summit sometimes a little flattened; dorsally confluent with the post-median lobe, set a considerable distance from the posterior margin, leaving a wide posterior flange in the males. Surface apparently smooth.

Females like males, except for strong posterior inflation, which practically obliterates the true posterior lobe, but does not affect the posterior sulcus. The inflation is well defined below, leaving a distinct post-ventral flange.

An average left male valve from New York measures length 1.22 mm., height 0.68 mm., convexity 0.28 mm.

Material from Pennsylvania, as here illustrated, is left in this species, although it differs in minor but apparently persistent details from the New York specimens. In the Pennsylvania specimens the sulci, particularly the anterior sulcus, are narrower than in those from New York; the summits of the anterior and posterior lobes are somewhat more definitely flattened; the ventral confluence of the median lobes has a stronger forward swing, projecting into the lower part of the anterior sulcus. The anterior lobe and sulcus are not so crescentic as in the New York material, and the anterior lobe tends to be farther from the anterior margin. In the females the

posterior lobe is not so thoroughly obliterated, and the post-dorsal angle is somewhat more acute. The greater width of the sulci makes the New York material look comparatively more emaciated, and makes the anterior and posterior lobes appear more prominent.

These differences may have some stratigraphic as well as geographic value. Thus the New York specimens occur with a profusion of *Paraechmina spinosa* and *P. abnormis*. The Pennsylvania variety occurs with a profusion of *Paraechmina postica*, *Kloedenella cornuta* and its variety *praenuntia*, and in part with *Drepanellina clarki*, none of which are known in New York, while *Paraechmina spinosa* and *P. abnormis* are known in only the lower part of the range of the Pennsylvania material.

Occurrence.—The New York specimens here illustrated were collected by the writer from the Rochester shale on the east side of the gorge of the Niagara River, New York, and occur on slabs with *Paraechmina spinosa* and *P. abnormis*. The exact horizon was not determined, but is probably a little above the middle of the formation. The Pennsylvania material is persistent and moderately common in the upper part of the *Drepanellina clarki* zone of the Rochester shale, and continues from that zone into the overlying *Kloedenella cornuta-Schuchertella elegans* beds of the *Whitfieldella marylandica* zone, which is placed by the writer in the base of the McKenzie formation. Using the horizon where *D. clarki*, *Camarotoechia neglecta*, and *Stropheodonta* aff. *S. pleuristriata* suddenly disappear as the top of the Rochester shale, the Pennsylvania material occurs as follows: 1 foot below, and 1 foot above top of the Rochester shale, Lakemont, Pa.; ½ foot below, 1½ and 4 feet above top of Rochester shale, route 103, 1½ miles south of Lewistown, Pa.; 7, ¼, feet below, ¼, 2, 4, 5, 5½, 8¾ feet above top of Rochester shale, road to McElhatten, 1 mile east of Castanea, near Loch Haven, Pa.

DIZYGOPLEURA PERRUGOSA Ulrich and Bassler

Plate 28, figures 7*a–c*, 8*a–c*

Dizygopleura perrugosa ULRICH and BASSLER, *1923*, Maryland Geol. Survey, Silurian, p. 700, pl. 60, fig. 26.

This species is characterized by the remarkably elevated and carinate nearly vertical ridges and wide sulci that extend fully across the valve, except that the anterior sulcus is terminated just above the ventral margin, and the true median sulcus extends only about halfway across the valve, the median groove below this being simply a hollow between the ventral parts of the strongly elevated post-median and antero-median ridges. The dorsal loop and crest of the right valve, formed by confluence of the dorsal ends of the two median ridges, is a conspicuous feature. The dorsal end of the anterior ridge is not involved in this crest, as it is in most species of the genus. Because of the absence of this crest, and the greater fullness of the antero-ventral region, the left valve is quite different in aspect from the right. However, the relative height of the anterior part of the figured male left valve is somewhat greater than usual. The posterior inflation of the female makes the slope from the summit of the posterior lobe to the posterior margin convex instead of concave, but is not conspicuous, and does not greatly modify the appearance of the valve.

The figured large female right valve measures length 1.42 mm., height 0.88 mm., thickness or con-

vexity to summit of ridges 0.44 mm. A large male valve from the upper McKenzie near Bedford, Pa., measures length 1.50 mm., height 0.88 mm., convexity 0.46 mm.

The extraordinary elevation of the ridges, and particularly of the ventral parts of the median ridges, differentiates this species from all other described members of the genus.

Occurrence.—D. perrugosa is cited from the middle part of the McKenzie at Cumberland, Maryland, but all of the writer's specimens are from the *Kloedenella gibberosa* zone of the upper McKenzie at Cessna, 11 miles north of Bedford, Pa.; along the Lincoln Highway about 3 miles west of Bedford; Lakemont, near Altoona, Pa.; and at Mt. Union, Pa. The species is never abundant, but is fairly persistent.

DIZYGOPLEURA CONJUGATA F. M. Swartz, n. sp.
Plate 29, figures 7*a–d*, 8*a–d*; plate 30, figure 10

Male carapace subelliptical, female carapace subovoid in dorsal view, the lobation moderately conspicuous; hinge tooth of left valve strong, scarcely marked by an extension from the anterior sulcus; each valve with a well marked dorsal shoulder bordering the hinge, and widest above the posterior sulcus, the angulation of the shoulder of the right valve elevated into a low hump; male valve subrectangular in side view, with the posterior margin almost as rounded as the anterior, except that the post-dorsal angle is sharp though obtuse, while the anterior margin rounds gradually into the dorsal margin; post-dorsal region more extended in the female. Ventral margin slightly sinuate. Left valve overlaps a little on the right along the free margins.

Median sulcus large, almost square, floor peculiarly hollowed, broadly rounded; anterior and posterior sulci almost equal, outwardly crescentic, fairly deep, of moderate width, the anterior sulcus a trifle wider and deeper than the other; each of these sulci is definitely terminated above and below, except that there is a more or less distinct longitudinal groove connecting the ventral ends of the sulci, paralleling the ventral margin, and more or less undercutting the ventral conjunction of the post-median and antero-median lobes; and, in the left valve, there is a faint dorsal extension from the anterior sulcus onto the hinge tooth. Posterior lobe of male crescentic, long, elevated, narrower than the anterior lobe, well defined, set a considerable distance from the posterior margin. In the females, the posterior inflation is distinct, and makes the slope from the posterior lobe to the posterior margin convex, although it does not fully obliterate the lobe.

An average male carapace measures length 1.00 mm., height 0.58 mm., thickness 0.47 mm.

Two species of *Dizygopleura* have been described which are said to have a ventral furrow connecting the two outer sulci. The first of these, *D. concentrica* Ulrich and Bassler,[31] is semicircular in outline, and apparently has the hinge angulated at both ends. It is close to *Welleria* and *Kloedenia*, and does not belong in

[31] *Maryland Geol. Survey*, Silurian, pp. 691, 692, pl. 61, fig. 11, 1923.

EXPLANATION OF PLATE 29

FIGS. 1 —*Dizygopleura hieroglyphica* (Krause) after Van Veen, ×28. Left side of carapace. Silurian drift of Germany. See discussion comparing *Dizygopleura* and *Poloniella*.

2*a,b*—*Dizygopleura reticulata* F. M. Swartz, n. sp., males, ×21. 2*a*, Left view of small carapace. 2*b*, Dorsal view of carapace with a hole just behind middle of the dorsal margin. From 53 feet above base of the McKenzie formation, Lakemont, near Altoona, Pa.

3*a,b*—*Dizygopleura reticulata* F. M. Swartz, n. sp., females, ×21. 3*a*, Left view of carapace. 3*b*, Dorsal view of another carapace. Note marked similarity of hinge tooth in 2*b* and 3*b*. From 53 feet above base of the McKenzie formation, Lakemont, near Altoona, Pa.

4*a–f*—*Kloedenella intermedia* (Ulrich and Bassler), males, ×21. 4*a*, Right view of carapace. 4*b*, Right view of another carapace. 4*c*, Left view of carapace. 4*d*, Left view of another carapace. 4*e*, Dorsal view of a carapace. 4*f*, Ventral view of a carapace. Many specimens are somewhat thicker than these. From about 55 feet above base of the McKenzie formation, 3.5 feet above foot wall of quarry 1.5 miles east of Castanea, Pa.

5*a–g*—*Kloedenella intermedia* (Ulrich and Bassler), females, ×21. 5*a*, Right view of carapace. 5*b*, Right view of another carapace. 5*c, d*, Left views of carapaces, dorsal crests of right valves not shown. 5*e*, Dorsal view of thick carapace; compare hinge tooth with that of 4*e*. 5*f*, Posterior view of carapace. 5*g*, Ventral view of an exceptionally large carapace. From about 55 feet above base of the McKenzie formation, 3.5 feet above foot wall of quarry 1.5 miles east of Castanea, Pa.

6*a,b*—*Kloedenella cornuta* var. *praenuntia* F. M. Swartz, n. var., males, ×22. 6*a*, Side view of large right valve. 6*b*, Side view of a right valve, incomplete posteriorly. From Rochester shale, 34 feet above Keefer sandstone, Lakemont, near Altoona, Pa.

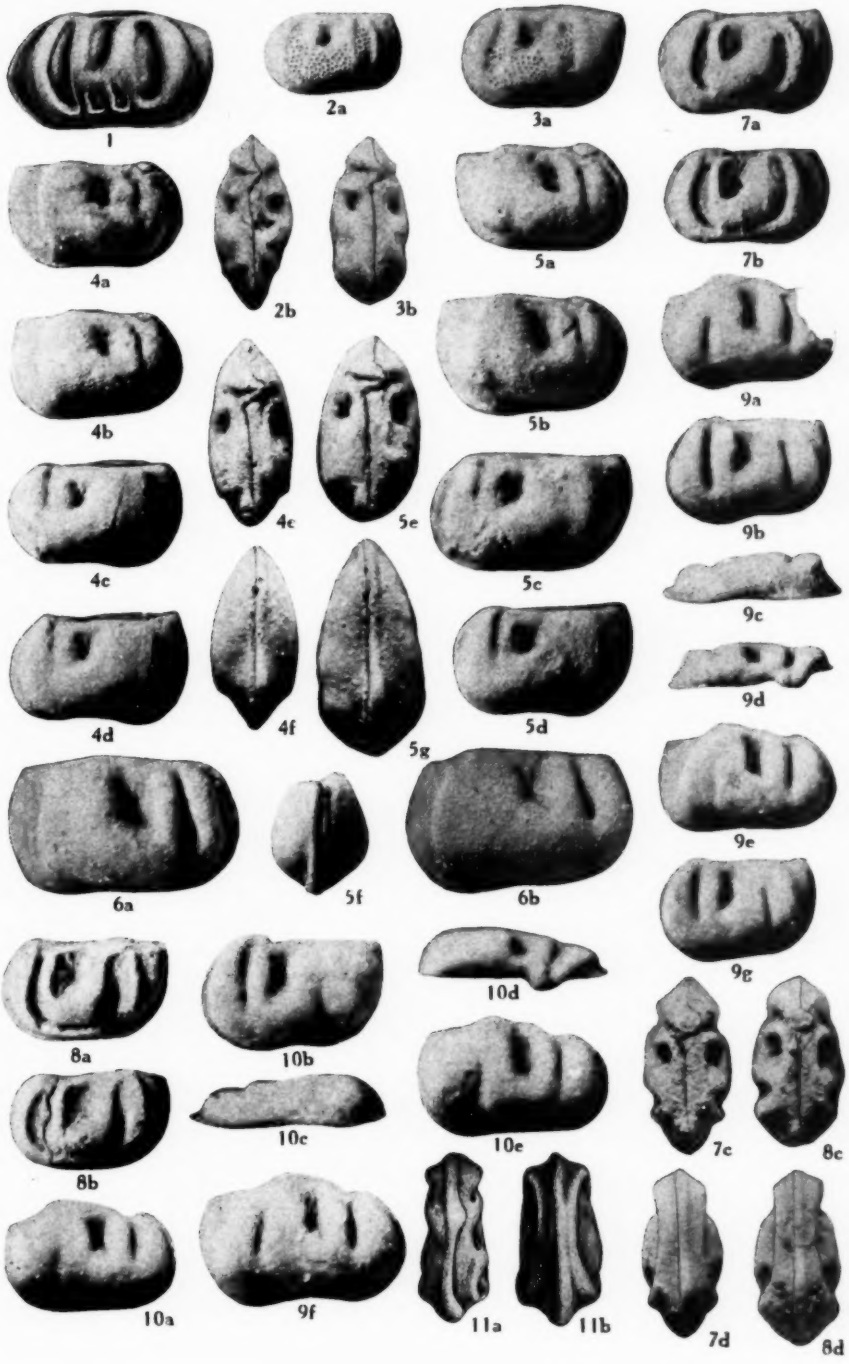
7*a–d*—*Dizygopleura conjugata* F. M. Swartz, n. sp., males, ×22. 7*a*, Side view of left valve with poorly developed ventral groove and dorsally shortened posterior sulcus. 7*b*, Side view of left valve with a good ventral groove. 7*c*, Dorsal view of carapace; note dorsal shoulders. 7*d*, Ventral view of same specimen. From 12.5 feet above base of the McKenzie formation, Route 103, 1.5 miles south of Lewistown, Pa.

8*a–d*—*Dizygopleura conjugata* F. M. Swartz, n. sp., females, ×22. 8*a,b*, Side view of left valves with distinct posterior inflations and strong ventral grooves. 8*c*, Dorsal view of carapace; note dorsal shoulders. 8*d*, Ventral view of carapace. Specimen shown in 8*a* from 12.5 feet above base of the McKenzie formation, Route 103, 1.5 miles south of Lewistown, Pa. Others from 15.5 feet above base of the McKenzie formation, 1 mile east of Castanea, Pa.

9*a–g*—*Dizygopleura brevisulcata* F. M. Swartz, n. sp., males, ×22. 9*a*, Side view of incomplete right valve showing strong dorsal crest and narrow short doubly terminated posterior sulcus. 9*b*, Side view of typical left valve lacking the dorsal crest and with full anteroventral region. 9*c*, Ventral view of same. 9*d*, Dorsal view of same. Note flattening of summits of lobes and valve as a whole, and the strong outer angulation of the posterior lobe. 9*e*, Side view of elongate right valve with weak posterior sulcus. 9*f*, Side view of the largest right valve seen. 9*g*, Side view of left valve. From 110 feet above base of the McKenzie formation, Lakemont, near Altoona, Pa.

10*a–e*—*Dizygopleura brevisulcata* F. M. Swartz, n. sp., females, ×22. 10*a*, Side view of typical right valve. 10*b*, Side view of typical left valve with exceptionally prominent hinge tooth. 10*c*, Ventral view of left valve. 10*d*, Dorsal view of left valve. 10*e*, Side view of elongate right valve. From 110 feet above base of the McKenzie formation, Lakemont, near Altoona, Pa.

11*a,b*—*Poloniella devonica* Gurich, after Van Veen. Magnification unknown. 11*a*, Dorsal view of carapace. 11*b*, Ventral view of carapace belonging supposedly to a female. Middle Devonian of Europe. See discussion comparing *Dizygopleura* and *Poloniella*, and pl. 30, figs. 9*a*, *b*.



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Dizygopleura. The second, *D. concentric* var. *subquadrata* Ulrich and Bassler,[32] is very close to *D. brevisulcata* F. M. Swartz n. sp., but the posterior sulcus is more dorsal in position, and the figured specimen is small. The figured specimen, at least, does not have a longitudinal ventral furrow comparable to that of *D. conjugata*.

Occurrence.—This is a persistent species at and perhaps a little above the top of the *Whitfieldella marylandica* zone, which is here included in the basal part of the McKenzie formation. Using the horizon at which *Drepanellina clarki* suddenly disappears as the top of the Rochester shale, *D. conjugata* has been found as follows: 12 feet above base of McKenzie, route 103, 1½ miles south of Lewistown, Pa.; 15½ to 16 feet above base of McKenzie, road to McElhatten, 1 mile east of Castanea, near Loch Haven, Pa.; also top of *Whitfieldella marylandica* zone, Wagoner's Mill, near New Bloomfield, Pa.; along Lincoln Highway 3 miles west of Bedford, Pa.; and 24 feet above top of Keefer sandstone, east of Crabbottom, north of Monterey, Va., where *W. marylandica* is abundant 10½ and 19 feet above top of Keefer.

DIZYGOPLEURA BREVISCULTA F. M. Swartz, n. sp.
Plate 29, figures 9*a–g*, 10*a–e*

Male carapace almost suboblong in dorsal view, because of marked flattening of sides, but somewhat thicker posteriorly than toward the front; female carapace subovoid in this view; hinge tooth of left valve of moderate size, broad, grooved by extension of the anterior sulcus; right valve more or less subovate in side view, with greatest height at posterior sulcus, because of the strong dorsal hump; left valve subrectangular, with greatest height near front; anterior margin broadly rounded, ventral margin slightly sinuate, posterior margin more or less truncated, somewhat recessive below; posterior cardinal angle sharp but slightly obtuse.

Anterior sulcus narrow, moderately deep, vertical, almost straight, extending only about two-thirds the distance across the valve, abruptly terminated below, set a considerable distance from the anterior margin, with the anterior lobe broadly rounded. Median sulcus rather narrow, its sides about parallel, extending about one-third the distance from the dorsal margin; posterior sulcus of male narrow, moderately deep, as a rule definitely terminated at both ends, and occupying only the middle third of its meridian; posterior lobe of male broad, strongly flattened, its outer margin sharply defined, and forming a strong crest above the steep concave posterior slope; the outer margin of this lobe is continued dorsally into the posterior margin of the dorsal crest in the right valve. Female valves with a strong posterior inflation, obliterating the true posterior lobe and sulcus, although the inflation is defined antero-ventrally by a short shallow vertical furrow. The inflation extends to the post-ventral margin, so there is no post-ventral flange. Surface apparently smooth.

An average male right valve measures length 1.02 mm., height with crest 0.68 mm., without crest 0.57 mm., convexity 0.22 mm.; the larg-

[32] *Maryland Geol. Survey*, Silurian, p. 692, pl. 61, fig. 12, 1923.

est observed specimen, a male right valve, measures length 1.17 mm., height with crest 0.74 mm., thickness 0.27 mm.

This species is a little suggestive of *Dizygopleura gibba* Ulrich and Bassler,[33] of the upper part of the McKenzie of Maryland, but in that species the lobation is much stronger, and the posterior sulcus is open ventrally. The females are suggestive of *D. acuminata* var. *prolapsa* Ulrich and Bassler,[34] because of the unusual ventral extent of the posterior inflation, but are considerably smaller. *D. concentrica subquadrata* Ulrich and Bassler[35] is closely related to this species, but is smaller, and the posterior sulcus is more dorsal in position.

Occurrence.—Rare 94 feet, common 105 feet, abundant 110 feet above base of the McKenzie formation, Lakemont, Pa.; common about 120 feet above base of the McKenzie, Mt. Union, Pa.; some questionable specimens about 160 feet above base of the McKenzie, quarry along road to McElhatten, 1½ miles east of Castanea, near Loch Haven, Pa.

DIZYGOPLEURA RETICULATA F. M. Swartz, n. sp.
Plate 29, figures 2*a*,*b* 3*a*,*b*

Carapace rather small, males elliptical, females subovoid in dorsal view; hinge tooth of left valve short, broad based, sharply triangular, marked by extension of anterior furrow; hinge bordered by flattened areas of moderate width; carapace subrectangular to subrhomboidal in side view, right valve with a low postmedian dorsal crest; anterior margin broadly rounded, ventral margin about straight or slightly sinuate, posterior margin truncated but convex; post dorsal angle slightly obtuse in males, more extended in females.

Dorso-median sulcus fairly deep, rather small, extending about one-third the distance from the dorsal margin; anterior and posterior sulci long, extending well across the valve, broad, but very shallow, and not well defined; anterior lobe broad, low, crescentic, not well defined; posterior lobe of male narrow, long, not strongly elevated, set well away from the posterior margin; posterior inflation of female well developed, obliterating the true posterior lobe, but not greatly modifying the posterior sulcus. Areas other than the lobes and the median sulcus, and including the areas below the median sulcus and behind the posterior lobe in the male, marked by coarse rounded pits, 0.02 mm. or less in diameter. These are absent on the posterior inflation of the female.

A large male carapace measures length 1.06 mm., height 0.62 mm., thickness 0.48 mm. A large female carapace measures about the same, but is much thicker in the posterior region.

This species is of the general type of *D. swartzi*, but is small, the sulci are very broad and very shallow, and the surface is marked by coarse pits.

Occurrence.—*D. reticulata* is common in the upper part of the *Whitfieldella marylandica* zone, here placed in the basal part of the

[33] *Maryland Geol. Survey*, Silurian, p. 684, pl. 59, fig. 25, 1923.
[34] *Maryland Geol. Survey*, Silurian, p. 685, pl. 60, figs. 10–12, 1923.
[35] *Maryland Geol. Survey*, Silurian, p. 692, pl. 61, fig. 12, 1923.

McKenzie formation, and also occurs somewhat higher in the lower McKenzie, as follows: 53 feet above the base of the McKenzie, Lakemont, Pa.; ¼, 1½, 10, and 20 feet above base of the McKenzie, 1 mile east of Castanea, near Loch Haven, Pa.; 8 feet above base of the McKenzie, Allenwood, near Watsontown, Pa.; 38 feet above Keefer sandstone, 3 miles west of Danville, Pa.; upper part of *W. marylandica* zone, Wagoner's Mill, near New Bloomfield, Pa.; upper part of *W. marylandica* zone, Rose Hill, Cumberland, Md.; about 8 feet above base of the McKenzie, 10 miles west of Petersburg, W. Va.; about 40 feet above base of the McKenzie, 10 miles north of Monterey, Va.

Genus KLOEDENELLA Ulrich and Bassler

KLOEDENELLA INTERMEDIA (Ulrich and Bassler)

Plate 29, figures 4*a–f*, 5*a–g*

Dizygopleura intermedia ULRICH and BASSLER, *1923*, Maryland Geol. Survey, Silurian, p. 688, pl. 60, figs. 15, 16.

Kloedenella scapha ULRICH and BASSLER, *1923*, Maryland Geol. Survey, Silurian, p. 677, pl. 59, figs. 4–9.

Male carapace more or less subovate in dorsal view, but posterior extremity strongly compressed; female carapace subovate in this view; hinge tooth of left valve strong, bearing extension of anterior sulcus; carapace subrectangular to subrhomboidal in side view; right valve with low inconspicuous dorsal crest; anterior margin broadly rounded; ventral margin slightly sinuate; posterior margin somewhat truncated, dorsal part more extended in the female than in the male; post-dorsal angle slightly obtuse. Posterior end generally a little higher than the anterior. Left valve overlaps a little on right along the free margins.

Median sulcus of moderate size, fairly deep, extending about one-third the distance from the dorsal margin. Anterior sulcus narrow, nearly vertical, rather shallow, short, gradually dying out about one-third below the dorsal margin; in the left valve this sulcus extends dorsally onto the hinge tooth, but in the right valve it curves posteriorly at its dorsal end. Antero-median lobe weak, rounded, somewhat depressed below the anterior lobe and the area below and behind the median sulcus. The posterior sulcus of *Dizygopleura* is absent in this species. There is, however, a depressed posterior area or flange, sharply defined on its anterior side, that is similar to the area behind the posterior lobe in *Dizygopleura*. In the females, the posterior inflation is strongly developed, obliterating most of the posterior flange of the male valve, but leaving a narrow post-ventral flange, while there is a suggestion of the dorsal part of the angulation that defines the posterior flange in the male valve. The inflation is defined antero-ventrally by a short shallow undefined vertical furrow, projecting upward from the post-ventral flange.

A fairly large male carapace measures length 1.06 mm., height 0.66 mm. with dorsal crest of right valve, 0.63 without this crest, thickness 0.48 mm. Female carapaces tend to be a little larger than the males, a rather large female carapace measuring length 1.15 mm., height with crest 0.73 mm., thickness 0.58 mm.

The weakness of the anterior sulcus, and the absence of the posterior sulcus, very definitely place this species in *Kloedenella*, and not in *Dizygopleura*, in the writer's opin-

ion. The constant association of *K. intermedia* and *K. "scapha"* in the lower third of the McKenzie, and their marked similarity except for the posterior inflation of *K. "scapha,"* indicates that the latter is the female of the former.

K. intermedia is subject to con-

EXPLANATION OF PLATE 30

FIGS. 1*a–e*—*Kloedenella cornuta* (Ulrich and Bassler), males, ×19. 1*a,b,d*, Side view of typical left valves showing posterior flange, postdorsal node and the constancy of anterior sulcus and dorsally terminated anteromedian lobe. 1*c*, Ventral view of the left valve shown in Fig. 1*b*. 1*e*, Side view of left valve with node on anteromedian lobe, showing punctae. Specimens shown in 1*a–d* from 1 foot above base of the McKenzie formation, Lakemont, near Altoona, Pa.; 1*e* from 2 feet above base of McKenzie formation, 1 mile east of Castanea, Pa.

2*a–d*—*Kloedenella cornuta* (Ulrich and Bassler), females, ×19. 2*a*, Side view of typical left valve. 2*b*, Dorsal view of same. 2*c*, Side view of another left valve. Note low postdorsal node and wide postventral flange; compare anterior sulcus and anteromedian lobe with those of the males. 2*d*, Side view of left valve with exceptionally strong furrow defining front of posterior inflation and showing surface punctae; the broken postdorsal node is exceptionally strong. Specimens shown in 2*a,b* from 3 feet above base of McKenzie formation, 2*c,d* from 1 foot above base of McKenzie formation, Lakemont, Pa.

3*a–e*—*Kloedenella nitida* Ulrich and Bassler, males, ×20. 3*a*, Side view of right valve with dorsal crest of maximum strength and showing fine surface punctae like other specimens. 3*b*, Left view of carapace. 3*c*, Ventral view of same. 3*d*, Side view of left valve. 3*e*, Dorsal view of carapace showing hingement and dorsal crests of the valve; note sunken anteromedian lobe. Specimens shown in 3*a, d*, from about 109 feet, others about 111 feet above base of the McKenzie formation, quarry 1.5 miles east of Castanea, Pa.

4*a–e*—*Kloedenella nitida* Ulrich and Bassler, females, ×20. 4*a*, Right view of carapace with dorsal crest of maximum strength. 4*b*, Right view of carapace with a hole just above and behind the median sulcus. 4*c*, Ventral view of same. 4*d*, Left view of carapace. 4*e*, Dorsal view of same; note greater divergence of dorsal shoulders than in Fig. 3*e*. From about 111 feet above base of the McKenzie formation, quarry 1.5 miles east of Castanea, Pa.

5*a–e*—*Eukloedenella sulcifrons* Ulrich and Bassler, males, ×20. 5*a*, Side view of typical left valve with comparatively large median sulcus. 5*b*, Dorsal view of same; note lack of distinct hinge tooth. 5*c*, Side view of left valve. 5*d*, Side view of right valve. 5*e*, Dorsal view of same, the posterior slope not concave. Specimens shown in 5*a–c* from 90 feet, others 94 feet above base of McKenzie formation, Lakemont, near Altoona, Pa.

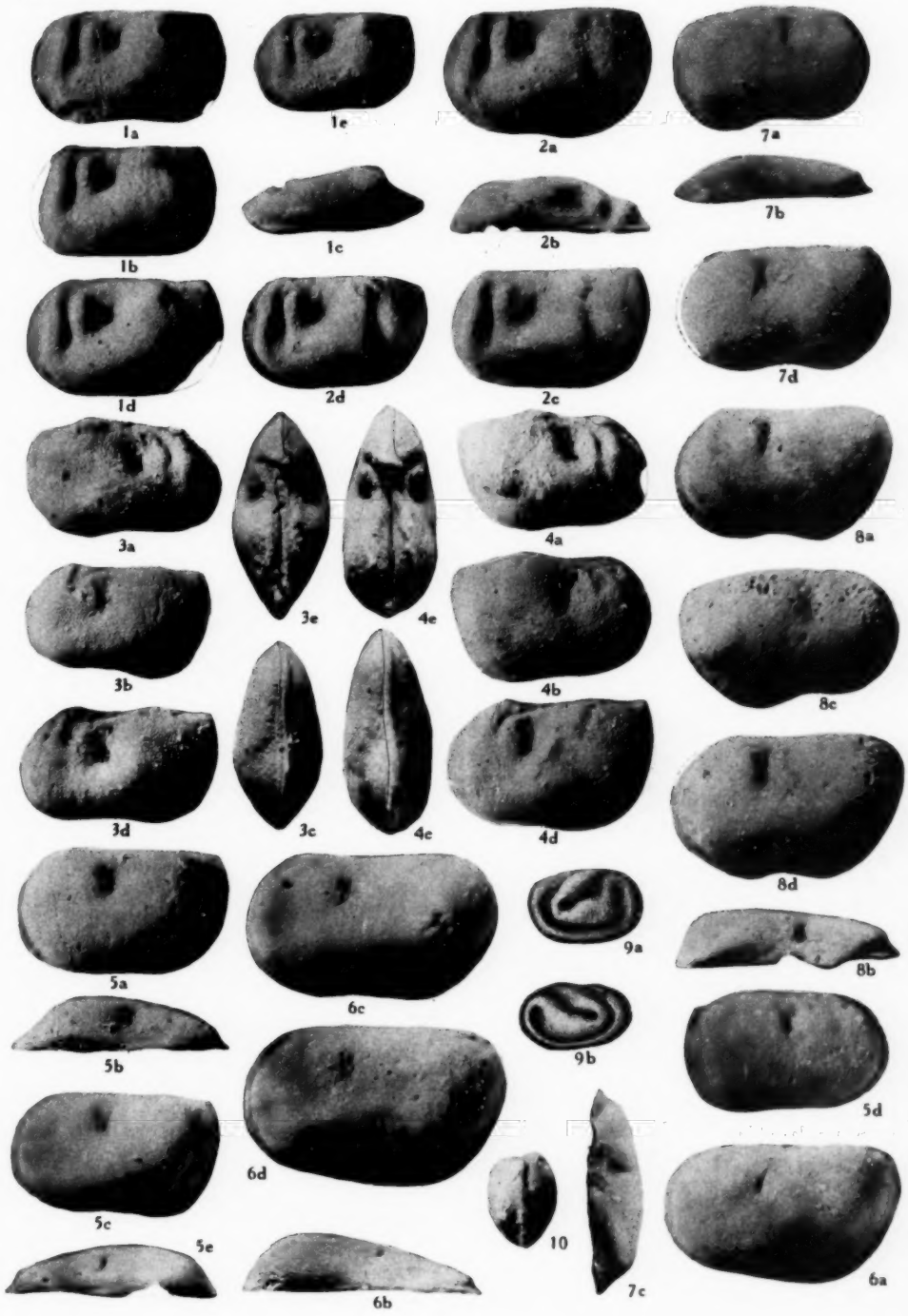
6*a–d*—*Eukloedenella sulcifrons* Ulrich and Bassler, females, ×20. 6*a*, Side view of left valve. 6*b*, Dorsal view of same. 6*c,d*, Side view of left valves showing variations in size and shape. Specimens shown in 6*a,b* from 94 feet, others from 90 feet above base of the McKenzie formation, Lakemont, near Altoona, Pa.

7*a–d*—*Eukloedenella sinuata* Ulrich and Bassler, males, ×20. 7*a*, Side view of right valve 7*b*, Ventral view of same. 7*c*, Dorsal view of same; note socket for hinge tooth. 7*d*, Side view of left valve. Specimens shown in 7*a–c* from upper McKenzie *Kloedenella gibberosa* zone, Lakemont, Pa.; 7*d* from lower part of this zone, Cessna, Pa.

8*a–d*—*Eukloedenella sinuata* Ulrich and Bassler, females, ×20. 8*a*, Side view of left valve. 8*b*, Dorsal view of same showing hinge tooth. 8*c*, Side view of right valve. 8*d*, Side view of left valve. Specimen shown in 8*a,b* from lower part of *Kloedenella gibberosa* zone, upper McKenzie formation, Cessna, Pa.; 8*c* from this zone at Lakemont, Pa.; 8*d* from this zone at Mount Union, Pa.

9*a,b*—*Poloniella devonica* Gurich, after Van Veen. Magnification unknown. 9*a*, Side view of left valve. 9*b*, Side view of right valve. Middle Devonian of Europe. See pl. 29, figs. 11*a,b*

10 —*Dizygopleura conjugata* F. M. Swartz, n. sp. Posterior view of a female carapace, ×20. From 15.5 feet above base of McKenzie formation, 1 mile east of Castanea, Pa. See pl. 29, figs. 7*a–d*, 8*a–d*.



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siderable variation in the strength of the angulation defining the posterior flange. In some specimens the angulation is strongly crested, as in the figured specimens; in others it is rounded. In a few specimens the post-dorsal angle is more extended than in those figured.

The posterior flange is suggestive of those of *K. cornuta*, *K. cornuta* var. *praenuntia*, and *Eukloedenella sulcifrons*, all of which are discussed in this paper, and also of those of two unnamed species, one from the upper part of the Rose Hill shale, or pre-Rochester part of the Clinton group of Maryland and Pennsylvania, and one from the upper part of the *Whitfieldella marylandica* zone, here included in the McKenzie. The Rose Hill species has a much larger median sulcus, and a weaker anterior sulcus. The *W. marylandica* zone species has a very weak anterior sulcus, the antero-median lobe is not depressed, and the hinge tooth of the left valve is obsolete. Accordingly, it is very suggestive of *E. sulcifrons*.

Occurrence.—*K. intermedia* is one of the most persistent and abundant species of the lower part of the McKenzie formation, generally ranging from about 40 feet to about 100 feet or more above the base of the formation, as follows: 51, 53, 56, 66, 82, 84, 90, 94, and 110 feet above the base of the McKenzie, Lakemont, near Altoona, Pa.; 33, 35, 40, 63, 97, 165 feet above base of the McKenzie, route 103, 1½ miles south of Lewistown, Pa.; about 90 feet and about 150 feet above base of the McKenzie, Mt. Union, Pa.; 22 feet above base of the McKenzie, along road 1 mile east of Castanea, near Loch Haven, Pa.; about 53, 56, 62, and 68 feet above base of the McKenzie, quarry 1½ miles east of Castanea, Pa.; 70 feet above base of the McKenzie, 3 miles west of Danville, Pa.; also in lower McKenzie near Howard, Pa., and near Watsontown, Pa.

KLOEDENELLA CORNUTA (Ulrich and Bassler)

Plate 30, figures 1*a–e*, 2*a–d*

Dizygopleura intermedia var. *cornuta* ULRICH and BASSLER, *1923*, Maryland Geol. Survey, Silurian, p. 688, pl. 60, fig. 17.

Dizygopleura proutyi ULRICH and BASSLER, *1923*, Maryland Geol. Survey, Silurian, p. 682, pl. 59, figs. 21–23.

probably *Dizygopleura pricei* ULRICH and BASSLER, *1923*, Maryland Geol. Survey, Silurian, p. 682, pl. 59, fig. 24.

Ulrich and Bassler described the males of this species as a variety of *Kloedenella intermedia*, differentiating them from that form because of the greater width of the post-ventral part of the posterior flange, and particularly because of the low post-dorsal node. There are additional important differences. Thus the anterior sulcus is much stronger than in *K. intermedia*, somewhat wider, particularly in its lower part, and is abruptly terminated at its lower end. Because of the greater strength of this sulcus, the anterior and antero-median lobes appear more elevated. The antero-median lobe is not sunken as it is in *K. intermedia*, and it is abruptly terminated some distance below the dorsal margin. The anterior hinge tooth of the left valve, so well developed in *K. intermedia*, is obsolete in this species. In the females, mostly placed in *Dizygopleura proutyi* by Ulrich and Bassler, the vertical furrow defining the lower part of the anterior margin of the posterior inflation is much stronger than in the females of *K. intermedia*, and the

inflation is more dorsal in position, with its ventral margin sharply defined, so as to leave a wide post-ventral flange. The females frequently show an inconspicuous post-dorsal node, visible in a strong cross light, and corresponding to, but usually much weaker than the node of the male. The type specimen of *D. pricei* appears to be an elongate female of this species. In exceptionally well preserved specimens, the surface is marked by fine shallow punctae.

In one male specimen, here retained in the species, the post-dorsal node is exceptionally strong, and there is a second node at the dorsal end of the antero-median lobe.

A large male valve measures length 1.36 mm., height 0.78 mm., convexity 0.28 mm. The females are generally a little larger than the males, a large specimen measuring length 1.45 mm., height 0.88 mm., convexity 0.34 mm.

Occurrence.—Throughout central Pennsylvania, *K. cornuta* forms a remarkably persistent zone, about 5 or 6 feet thick, in the lower half of the *Whitfieldella marylandica* zone, and just above the top of the range of *Drepanellina clarki* and *Camarotoechia neglecta*. The *K. cornuta* beds are here included in the base of the McKenzie, and the species occurs as follows: 1, 2, 3, 5, and 6 feet above base of the McKenzie, Lakemont, near Altoona, Pa.; 1–1½ feet above base of the McKenzie, route 103, 1½ miles south of Lewistown, Pa.; ½, 1½, 1¾, 2, 3, 3¼, 5 and 5½ feet above base of the McKenzie, road to McElhatten, 1 mile east of Castanea, near Loch Haven, Pa.; 4 feet above base of the McKenzie, Allenwood, near Watsontown, Pa.; 32 feet above Keefer sandstone, Danville, Pa.; 23 and 25 feet above Keefer sandstone, Saltillo, Pa.; 3 feet above base of the McKenzie, 10 miles west of Petersburg, W. Va.

KLOEDENELLA CORNUTA var. PRAENUNTIA
F. M. Swartz, n. var.
Plate 29, figures 6*a*,*b*

This variety is very close to *K. cornuta*, but lacks the post-dorsal node of that species. As in *K. cornuta*, the anterior sulcus is strong, somewhat wider near its ventral end, where it is abruptly terminated; the anterior and antero-median lobes are elevated, the antero-median lobe terminating a little below the hinge line, although not always so abruptly as in *K. cornuta*. The posterior flange is of the same size and character. The female is essentially the same as in *K. cornuta*, and many of the specimens heretofore referred to *Dizygopleura proutyi* and *D. pricei* are undoubtedly the females of this variety.

A large elongate male right valve measures length 1.34 mm., height 0.79 mm., convexity 0.38 mm.

The characters of the anterior sulcus and anterior and antero-median lobes readily distinguish this species from *K. intermedia*.

The lack of the post-dorsal node seen in *K. cornuta* is of stratigraphic value, as *K. cornuta* is found only in the beds just above the top of the range of *Drepanellina clarki*, while the variety *praenuntia* appears in the upper ten feet or so of the *D. clarki* zone. Not all of the specimens of the *Kloedenella cornuta* beds have a distinct post-dorsal node, but so long as node bearing specimens are present, the writer has been referring the whole assemblage to *K. cornuta*.

Occurrence.—9 and 1 feet below the top of the Rochester shale, Lakemont, Pa.; 7 and ¼ feet below the top of the Rochester shale,

road to McElhatten, 1 mile east of Castanea, Pa.; near top of Rochester shale, Mann's Gap, near Lewistown, Pa.

KLOEDENELLA NITIDA Ulrich and Bassler
Plate 30, figures 3*a–e*, 4*a–e*

Kloedenella nitida ULRICH and BASSLER, *1923*, Maryland Geol. Survey, Silurian, p. 679, pl. 59, fig. 14.

Male carapace subelliptical, female carapace subovoid in dorsal view; left valve with strong hinge tooth, bearing an extension of the anterior sulcus; each valve with a dorsal shoulder and angulation, the angulation of the right valve forming a more or less distinct dorsal crest; carapace subrhomboidal in side view, the greatest diameter obliquely from the antero-ventral to the post-dorsal region; anterior margin broadly rounded, fullest in its lower part; ventral margin gently sinuate, fuller behind than in front; posterior margin more or less truncated, most extended about one-third below the dorsal angle in the males, the post-dorsal angle being slightly obtuse; post-dorsal angle more protuberant in the females. Left valve overlaps a little on the right along the free margins.

Dorso-median sulcus of moderate size, its lower margin a little more than one-third below the dorsal margin of the valve; anterior sulcus weak, poorly defined, dying out gradually below, extending as much as halfway across the valve; in the left valve, there is an extension from the anterior sulcus onto the hinge tooth; in the right valve this sulcus turns backward at its upper end, more or less parallel to the adjacent margin, and in the left valve there is a suggestion of a similar posterior branch near the dorsal end of the anterior sulcus. The antero-median lobe is weak, and is somewhat sunken below the level of the anterior lobe, and of the areas below and behind the median sulcus. In the males, the greatest convexity is a little behind the median sulcus, the surface descending gradually, with a broadly and gently convex curvature to the posterior margin. There is a slight concavity post-ventrally that forms an undefined post-ventral flange. In the females there is a strong posterior inflation, sufficiently well defined below to form a distinct post-ventral flange, and with its antero-ventral margin marked by a short undefined vertical furrow, extended dorsally from the post-ventral flange. Surface of well preserved specimens minutely punctilose.

A large male carapace measures length 1.37 mm., height with right dorsal crest 0.80 mm., without this crest 0.77 mm., thickness 0.61 mm. A large female carapace measures length 1.36 mm., height 0.84 mm. with crest, 0.79 mm. without crest, thickness 0.61 mm. Diameter of surface punctae about 0.01 mm. or less.

The dorsal crest of the right valve is somewhat variable in strength, the figured right view of a male carapace showing it at its maximum strength. The specimen figured by Ulrich and Bassler is somewhat shorter, and has a more obtuse post-dorsal angle, than most of the writer's material. *Kloedenella immersa* Ulrich and Bassler[36]

[36] *Maryland Geol. Survey*, Silurian, p. 680, pl. 59, figs. 15, 16 1923.

appears to be a particularly elongate variety of *K. nitida*. The female form was not distinguished by Ulrich and Bassler, although it is represented among the mounted cotypes.

K. intermedia has a "sunken" antero-median lobe, much like that of *K. nitida*, and it seems possible that the latter was derived from the variety of the former in which the angulation defining the posterior flange is weak and rounded.

Occurrence.—*K. nitida* is an abundant and persistent species, occurring in a zone corresponding to the beds a little below the middle of the typical McKenzie of western Maryland, as follows: 82, 84, 130, and 140 feet above the base of the McKenzie, Lakemont, near Altoona, Pa.; about 75, 80, 130, 140, and 150 feet above the base of the McKenzie, Mt. Union, Pa.; 94, 96, and 165 feet above base of the McKenzie, route 103, 1½ miles south of Lewistown, Pa.; about 105, 107, 109, 115, 117, 119, and 123 feet above base of the McKenzie, quarry 1½ miles east of Castanea, near Loch Haven, Pa.; about 110–113, 118–121, and 127–128 feet above base of the McKenzie, Reading R. R., 2½ miles east of Montoursville, Pa.; about 145 feet above base of the McKenzie, highway 3 miles west of Danville, Pa.; about 115 and 185 feet above base of the McKenzie, gap at Howard, Pa.; and in the McKenzie, at Kantz, near Selinsgrove, Pa., and at Cessna, 11 miles north of Bedford, Pa.

Genus EUKLOEDENELLA Ulrich and Bassler

EUKLOEDENELLA SULCIFRONS Ulrich and Bassler

Plate 30, figures 5*a–e*, 6*a–d*

Eukloedenella sulcifrons ULRICH and BASSLER, *1923*, Maryland Geol. Survey, Silurian, pp. 673, 674, pl. 58, figs. 10–12.

Eukloedenella longula ULRICH and BASSLER, *1923*, Maryland Geol. Survey, Silurian, p. 675, pl. 58, fig. 14.

probably *Eukloedenella bulbosa* ULRICH and BASSLER, *1923*, Maryland Geol. Survey, Silurian, p. 675, pl. 58, fig. 18.

The males of this species are characterized by the broadly convex, smooth surfaced valves, high concave posterior slope making a wide posterior flange, and the rather small dorso-median pit, placed about one-fourth below the dorsal margin, somewhat in front of the middle of the valve. The floor of the pit is generally somewhat crinkled. The post-dorsal angle is distinct though obtuse; each valve has a narrow dorsal flattening or shoulder in the posterior half, so that in a complete carapace the hinge would be somewhat impressed; the edge of the shoulder forms a very low dorsal hump in the right valve; the hinge tooth of the left valve is obsolete or nearly so. The anterior margin is broadly rounded, passing gradually into the dorsal and ventral margins; the ventral margin is slightly sinuate; the posterior margin is somewhat recessive below. There is a narrow flattened border around the anterior margin. There is sometimes a suggestion of a shallow undefined anterior sulcus, extending one-third or so across the valve, and seen only under a strong cross light.

The females are considerably longer than the males, particularly in the part behind the median sulcus. The posterior inflation is strong, though undefined; it obscures the post-dorsal angle, and obliterates all but the ventral part of the posterior flange of the male.

A large male valve measures length 1.45 mm., height 0.86 mm., convexity 0.35 mm. An average female valve measures length 1.56 mm., height 0.90 mm., convexity 0.38 mm.; the

largest observed female valve measures length 1.78 mm., height 1.02 mm., convexity 0.43 mm.

The males of this species are somewhat suggestive of those of *Kloedenella intermedia*, because of the posterior flange, but this is a larger form, the anterior sulcus is never distinctly developed, the median sulcus is relatively much smaller and shallower, there is no suggestion of the depressed or sunken antero-median lobe of that species, so that the surface in front of the median sulcus is much more regularly convex and comparatively broader, and the hinge tooth is obsolete. There is greater difficulty in distinguishing an unnamed species occurring in the upper part of the *Whitfieldella marylandica* zone, that the writer has mistakenly identified as *E. sulcifrons*.[37] This species has the posterior flange of *E. sulcifrons* and *K. intermedia*, the anterior sulcus is stronger than that of the former but weaker than that of the latter, the antero-median lobe is not sunken, and the hinge tooth is obsolete. The non-sunken antero-median lobe, and the absence of the hinge tooth definitely removes this material from *K. intermedia*. Close comparison with *E. sulcifrons* shows that it is smaller, has a somewhat stronger anterior sulcus, the area in front of the median sulcus is not so broad and flattened, and the median sulcus is somewhat larger and deeper.

Associated with the typical specimens of *E. sulcifrons* are others in which the posterior slope is not concave. So long as these are associated with typical material, and have a distinct crest or angulation at the top of the posterior slope, they have been left in *E. sulcifrons* by the writer. In other specimens the top of the posterior slope is not distinctly angulated, and as this form occurs in part without *E. sulcifrons*, the writer has been identifying it as *E. simplex* Ulrich and Bassler.[38]

E. longula Ulrich and Bassler appears to be the female of *E. sulcifrons*, although in the specimen figured by those authors the post-ventral flange is not shown, and the pit is large. *E. bulbosa* Ulrich and Bassler appears to be a variety of the female of *E. sulcifrons*, with a shallow depression defining the anterior side of the posterior inflation, although as illustrated the median pit is large and extends nearly to the dorsal margin. It is probable that the material described as *E. longula* and *E. bulbosa* has been in part the females of *E. simplex*.

Occurrence.—Abundant 90 and 94 feet, small variety 110 feet above base of the McKenzie at Lakemont, near Altoona, Pa.; common about 95 and 100 feet above base of the McKenzie, Mt. Union, Pa.; abundant about 130 and 170 feet above base of the McKenzie, quarry along road to McElhatten, 1½ miles east of Castanea, Pa.; abundant about 155–160 and 163–164 feet above base of the McKenzie, along Reading R. R., 2½ miles east of Montoursville, Pa.; common about 85 feet above base of the McKenzie, 3 miles west of Danville, Pa.

[37] *Geol. Soc. Amer., Bull.*, vol. 42, pp. 627, 630, 1931.

[38] *Maryland Geol. Survey*, Silurian, p. 671, pl. 57, figs. 22, 23, 1923.

EUKLOEDENELLA SINUATA Ulrich and Bassler

Plate 30, figures 7*a–d*, 8*a–d*

Eukloedenella sinuata var. *angulata* ULRICH and BASSLER, *1923*, Maryland Geol. Survey, Silurian, p. 672, pl. 57, figs. 28–31, probably not pl. 58, fig. 1.

Eukloedenella sinuata ULRICH and BASSLER, *1923*, Maryland Geol. Survey, Silurian, p. 671, pl. 57, figs. 24–27.

This upper McKenzie species is characterized by the strongly sinuate ventral margin, although this margin appears less sinuate in the right than in the left valve. The dorso-median sulcus is narrow, of moderate length and depth. There is no suggestion of an anterior sulcus. There is a distinct lappet-like anterior hinge tooth in the left valve, and a corresponding socket in the other. The right valve tends to have a low dorsal hump. In the males, the post-dorsal angle is distinct though obtuse, and the posterior slope makes an angle of 45 degrees or less with the plane between the two valves. In the females there is a strong though poorly defined posterior inflation that obscures the post-dorsal angle, so that this part of the margin is rounded; the posterior slope is very steep; the ventral margin of the inflation is moderately well defined, leaving a broad post-ventral flange.

A male right valve measures length 1.38 mm., height with low dorsal hump 0.84 mm., without hump 0.78 mm., convexity 0.32 mm. A female left valve measures length 1.48 mm., height 0.92 mm., convexity 0.34 mm.

The females of this species were described as *E. sinuata* by Ulrich and Bassler, the males being separated as *E. sinuata* var. *angulata* because of the distinct post-dorsal angle.

Occurrence.—*E. sinuata* is an abundant species in the lower part of the *Kloedenella gibberosa* zone of the upper third of the McKenzie formation in south central Pennsylvania. It occurs at this horizon at Cessna, 11 miles north of Bedford, Pa.; Lakemont, near Altoona, Pa.; and at Mt. Union, Pa. Farther north, as at Lewistown, Pa., the species is not present because the horizon has passed laterally into the basal part of the Bloomsburg red shale.

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CONODONTS AND FISH REMAINS FROM THE CHEROKEE, KANSAS CITY, AND WABAUNSEE GROUPS OF MISSOURI AND KANSAS

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ABSTRACT

Several new genera and many new species of conodonts and other fish remains are described rom the Pennsylvanian of Missouri and Kansas.

INTRODUCTION

The detailed correlation of Pennsylvanian rocks is often a difficult task but in many cases an exceedingly important and necessary one. In a large part the difficulty of such correlations is caused by the great stratigraphic range of many invertebrate species and the frequent necessity of correlation from well cuttings. Recent work by the writer on conodonts from many states indicates that further knowledge of these fossils may supply the means of overcoming some of the previous difficulties of Pennsylvanian correlation.

Before conodonts can be of maximum value, however, it is necessary that individual faunas be described and stratigraphic ranges of species be determined. The present paper is one of a series in which the writer hopes to describe conodont faunas that he has secured from the Pennsylvanian formations of the United States. This series will be followed by papers describing the distribution of each species in the Pennsylvanian formations. Because of this plan a discussion of species distribution is omitted in the following descriptions.

The stratigraphic use of conodonts is not new but appears to be widespread. They were used for stratigraphic purposes as early as 1915 by Ulrich[1] who employed them to correlate the Chattanooga shale, and have been used since then by several investigators including micropaleontologists engaged in petroleum work.

The specimens described in this paper were collected from the Cherokee, Kansas City, and Wabaunsee groups of Missouri and Kansas. The exact localities and horizons where the types were found are listed below and are designated by numbers in connection with each specific description. The types are deposited in the Gunnell Collection.

[1] Ulrich, E. O., *Geol. Soc. America, Bull.*, vol. 26, pp. 96–99, 1915.

The specimens of some genera are broken, but their fractured edges can be distinguished on the figures. A majority of the figures representing species of the genus *Idiognathodus* have the bar broken from the plate. However, the specific characters of the plate are sufficiently developed that the absence of the bar is not a hindrance in classification.

Some of the figures show that there exist right and left varieties of a species. However, in most instances the description and the figures of a species are based upon a single specimen.

The sides and aboral surfaces of many different species within a genus resemble each other so closely that only a few of these views are figured.

LOCALITIES

1—Cherokee shale, overlying Lexington coal, Lexington, Missouri.

2—Quarry at Leeds, Kansas City, Missouri.
- 2a—Kansas City group, Galesburg shale (below Stark shale).
- 2b—Kansas City group, basal shale of Winterset limestone.
- 2c—Kansas City group, black shale near base of Winterset limestone.
- 2d—Kansas City group, second black shale above base of Winterset limestone.
- 2e—Kansas City group, first shale above second black shale of Winterset limestone.
- 2f—Kansas City group, third black shale above base of Winterset limestone.

3—Main Street cut, Union Station, Kansas City, Missouri.
- 3a—Kansas City group, Chanute shale (Quivira), directly underlying Cement City limestone.
- 3b—Kansas City group, Iola limestone (Argentine).

4—Twelfth Street and Viaduct (West Bluff), Kansas City, Missouri.
- 4a—Kansas City group, basal Cherryvale shale, "4-foot shale" bed (Fontana).
- 4b—Kansas City group, Cherryvale shale, 6 feet 7 inches above base.
- 4c—Kansas City group, Cherryvale shale, between first and second limestones above base.
- 4d—Kansas City group, Cherryvale shale, one foot above second limestone from base (Wea).
- 4e—Kansas City group, Cherryvale shale, immediately underlying Drum (Westerville) limestone (Wea shale).

5—Twenty-ninth Street and Southwest Boulevard, Kansas City, Missouri.
- 5a—Kansas City group, basal Galesburg shale.
- 5b—Kansas City group, basal shale of Winterset limestone.
- 5c—Kansas City group, second black shale above base of Winterset.

6—Duntile quarry, Kansas City, Missouri.
- 6a—Kansas City group, Chanute shale (Quivira), directly underlying Cement City limestone.
- 6b—Kansas City group, Chanute shale, between Raytown and Iola limestones (Lane shale).

7—Wabaunsee group, Americus limestone (?). Three miles west of Bellevue, Kansas.

CLASSIFICATION AND ZOOLOGICAL POSITION

The genera here described are referred to Cyclostomata, Plagiostomi, and Osteichthyes. The typical conodonts and related forms are classified as Cyclostomata, and the other genera are referred to Plagiostomi or Osteichthyes. The conodonts are referred to the Cyclostomata because of the occurrence in the Mesozoic of a form intermediate between a tooth of the modern *Petromyzon* (cyclos-

tome) and certain Pennsylvanian conodonts. Many details of the present classification must be omitted because certain relationships have not been established between micro- and mega-fossils of fishes. Undoubtedly conodonts will aid in establishing many heretofore unknown evolutionary relationships among the vertebrates.

STRATIGRAPHIC PALEONTOLOGY

CHEROKEE FORMATION

Lexington member (type locality)

Idiognathodus fustiformis Gunnell, n. sp.
Lonchodus simplex ? Pander,
Lonchodina sp.
Prioniodus cacti Gunnell, n. sp.
Prioniodus dactylodus Gunnell n. sp.
Synprioniodina sp.

KANSAS CITY GROUP (TYPE LOCALITY)

Galesburg shale[2]

Idiognathodus cancellosus Gunnell, n. sp.
Idiognathodus harkeyi Gunnell, n. sp.
Idiognathodus cuneiformis Gunnell, n. sp.
Idiognathodus jugosus Gunnell, n. sp.
Idiognathodus siculus Gunnell, n. sp.
Idiognathodus modulatus Gunnell, n. sp.
Idiognathodus sulciferus Gunnell, n. sp.
Idiognathodus lobatus Gunnell, n. sp.
Idiognathodus clavatus Gunnell, n. sp.
Idiognathodus nodostriatus Gunnell, n. sp.
Idiognathodus porcatus Gunnell, n. sp.
Idiognathodus chiriformis Gunnell, n. sp.
Idiognathodus rugulatus Gunnell, n. sp.
Idiognathodus ruidus Gunnell, n. sp.
Idiognathodus biconvexus Gunnell, n. sp.
Idiognathodus liratus Gunnell, n. sp.
Streptognathodus clavatulus Gunnell, n. sp.
Paleoniscus sp.
Prionidus ? galesburgensis Gunnell, n. sp.

Winterset limestone

Bryantodus ? sp.
Fish scale
Hibbardella ? sp.
Hibbardella sp.
Holmesella equilaterata Gunnell, n. sp.
Holmesella parallelata Gunnell, n. sp.
Holmesella parallella Gunnell, n. sp.
Holmesella elongata Gunnell, n. sp.
Holmesella ornata Gunnell, n. sp.
Idiacanthus bellistriatus Gunnell, n. sp.
Idiognathodus erodus Gunnell, n. sp.
Idiognathodus fusiformis Gunnell, n. sp.
Idiognathodus spathodus Gunnell, n. sp.
Idiognathodus semipapulatus Gunnell, n. sp.
Idiognathodus megistus Gunnell, n. sp.
Idiognathodus lanceolatus Gunnell, n. sp.
Idiognathodus folium Gunnell, n. sp.
Idiognathodus cicatricosus Gunnell, n. sp.
Idiognathodus binodosus Gunnell, n. sp.
Idiognathodus wintersetensis Gunnell, n. sp.
Idiognathodus strigillatus Gunnell, n. sp.
Idiognathodus confragus Gunnell, n. sp.
Idiognathodus gemmiformis Gunnell, n. sp.
Idiognathodus vadosus Gunnell, n. sp.
Idiognathodus biliratus Gunnell, n. sp.
Idiognathodus cariniferus Gunnell, n. sp.
Idioprioniodus typus Gunnell, n. sp.
Moreyella typicalis Gunnell, n. sp.

Cherryvale shale[3]

Cooleyella cuspidata Gunnell, n. sp.
Cooleyella quadrilobata Gunnell, n. sp.
Cooleyella spatulata Gunnell, n. sp.
Cooleyella peculiaris Gunnell, n. sp.
Cooperella subsulcata Gunnell, n. sp.
Cooperella eroda Gunnell, n. sp.
Cooperella rectistriata Gunnell, n. sp.
Cooperella striatula Gunnell, n. sp.
Cooperella selluliformis Gunnell, n. sp.
Cooperella ? sp.
Cooperella typicalis Gunnell, n. sp.
Cooperella, sp.
Idiacanthus cameratus Gunnell, n. sp.
Idiognathodus symmetricus Gunnell, n. sp.

[2] Galesburg shale and Stark shale member of the Dennis limestone—R. C. Moore.

[3] The "Cherryvale shale" of Hinds and Greene at Kansas City includes the Fontana shale, Block limestone and Wea shale of present classification of the Kansas Geological Survey. The "Drum limestone" of Hinds and Greene, which overlies their "Cherryvale" is now known to be the Westerville limestone, type locality in Iowa.—R. C. Moore.

Idiognathodus rotundus Gunnell, n. sp.
Idiognathodus cherryvalensis Gunnell, n. sp.
Idiognathodus corrugatus Gunnell, n. sp.
Idiognathodus strigillatus Gunnell, n. sp.
Idiognathodus walteri Gunnell, n. sp.
Idiognathodus simplex Gunnell, n. sp.
Moreyella trilobata Gunnell, n. sp.
Moreyella aviculiformis Gunnell, n. sp.
Streptognathodus sulcatus Gunnell, n. sp.
Streptognathodus multinodosus Gunnell, n. sp.
Streptognathodus sulciferus Gunnell, n. sp.
Streptognathodus corrugatus Gunnell, n. sp.
Streptognathodus spatulatus Gunnell, n. sp.
Streptognathodus subdivisus Gunnell, n. sp.
Streptognathodus ruidus Gunnell, n. sp.
Streptognathodus rugosus Gunnell, n. sp.
Streptognathodus holmesi Gunnell, n. sp.
Paleoniscus sp.
Petrodus ? sp.
Cavusgnathus lauta Gunnell, n. sp.
Williamsella typicalis Gunnell, n. sp.
Williamsella ? sp.

Chanute shale[4]

Bryantodus delicatus Gunnell, n. sp.
Bryantodus rugosus Gunnell, n. sp.
Bryantodus strigatus Gunnell, n. sp.
Bryantodus cameratus Gunnell, n. sp.
Bryantodus strigillatus Gunnell, n. sp.
Euprioniodina ? sp.
Fish tooth
Fortscottella gemmicula Gunnell, n. sp.
Hindeodella sp.
Holmesella speni Gunnell, n. sp.
Idiognathodus warei Gunnell, n. sp.
Idiognathodus kansensis Gunnell, n. sp.
Idiognathodus multinodosus Gunnell, n. sp.
Idiognathodus farrelli Gunnell, n. sp.
Idioprioniodus camurus Gunnell, n. sp.
Idioprioniodus striatus Gunnell, n. sp.
Kirkella indentata Gunnell, n. sp.
Kirkella typicalis Gunnell, n. sp.
Lonchodina ? sp.
Lonchodina ? sp.
Lonchodina ? sp.
Lonchodus sp.
Streptognathodus curvatus Gunnell, n. sp.
Streptognathodus strigillatus Gunnell, n. sp.
Streptognathodus clarki Gunnell, n. sp.
Streptognathodus minutus Gunnell, n. sp.
Streptognathodus chanutensis Gunnell, n. sp.
Paleoniscus sp.
Prioniodus sp.
Cavusgnathus missouriensis Gunnell, n. sp.
Cavusgnathus gigantea Gunnell, n. sp.
Cavusgnathus lauta, n. sp.
Gondolella merrilli Gunnell, n. sp.
Gondolella lingulata Gunnell, n. sp.
Gondolella sublanceolata Gunnell, n. sp.
Gondolella sinuata Gunnell, n. sp.
Subprioniodus sp.

Iola limestone[5]

Holmesella rhomboidalis Gunnell, n. sp.

WABAUNSEE GROUP

Americus limestone (?)

Cooleyella quinqueloba Gunnell, n. sp.
Cooperella striata Gunnell, n. sp.
Cooperella simplex Gunnell, n. sp.
Euprioniodina ? sp.
Fish scales ?
Hammondella crassa Gunnell, n. sp.
Hammondella globosa Gunnell, n. sp.
Holmesella crassa Gunnell, n. sp.
Idiacanthus trispinosus Gunnell, n. sp.
Idiacanthus sp.
Streptognathodus simplex Gunnell, n. sp.
Kirkella elliptica Gunnell, n. sp.
Streptognathodus elongatus Gunnell, n. sp.
Streptognathodus walteri Gunnell, n. sp.
Streptognathodus wabaunsensis Gunnell, n. sp.
Streptognathodus acuminatus Gunnell, n. sp.
Streptognathodus farmeri Gunnell, n. sp.
Streptognathodus flangulatus Gunnell, n. sp.
Paleoniscus sp.
Paleoniscus sp.
Subprioniodus sp.
Subprioniodus sp.
Williamsella typicalis, n. sp.
Williamsella striata Gunnell, n. sp.

[4] The Chanute shale, as previously identified at Kansas City and as here used, includes considerably more than the type Chanute. The divisions of the Kansas City "Chanute shale" are as follows, in upward order: (1) Quivira shale, (2) Drum (Cement City) limestone, (3) Chanute shale, (4) Iola (Raytown) limestone, (5) Lane shale.—R. C. Moore.

[5] The "Iola limestone" at Kansas City (as identified by Hinds and Greene) here indicated is not the true Iola but a higher formation called Argentine limestone.—R. C. Moore.

SYSTEMATIC PALEONTOLOGY

Class CYCLOSTOMATA

Family PRIONIODIDAE Ulrich and Bassler, 1926

Genus IDIOPRIONIODUS Gunnell n. gen.

Large, curving cusp with basal emarginations bearing one or more nodes or denticles on two different sides. Pulp cavity on aboral side.

Genotype, *I. typus* n.sp.

In addition to the new species herein described this new genus includes the following: *Prioniodus tridentatus* Gunnell, 1931; *Prioniodus lexingtonensis* Gunnell, 1931; *Prioniodus subacodus* Gunnell, 1931; *Prioniodus clarki* Gunnell, 1931; *Prioniodus missouriensis* Gunnell, 1931.

IDIOPRINIODUS TYPUS Gunnell, n. sp.
Plate 31, figure 47

Anterior basal extension curving laterally, and bearing five denticles on upper surface. Posterobasal extension with one small denticle occurring high on base of cusp. Cusp gently curving in one plane. Denticles, and cusp sub-biconvex in cross-section. The five denticles on one side of the basal extension distinguishes this species from *I. camurus*.

Winterset limestone, Loc. 2c. Gunnell coll. no. 1.

IDIOPRIONIODUS CAMURUS Gunnell, n. sp.
Plate 32, figure 30

Outline of base subelliptical. Denticles of equal size on opposite sides of basal margins. Cusp arching, subelliptical in cross-section, and gradually decreasing in size from base to summit.

The arching of the cusp throughout distinguishes this species from *I. striatus* in which the upper part of the cusp is straight.

Chanute shale (Quivira) Loc. 3a. Gunnell coll. no. 2.

IDIOPRIONIODUS STRIATUS Gunnell, n. sp.
Plate 32, figures 36, 37

Basal outline subelliptical. Two earlike nodes occur opposite each other on two longest sides of basal margins. Each side of cusp bearing striation which originates at base of each node. Cusp straight from about mid-height to summit.

The striations on the cusp distinguishes this species from *I. camurus*.

Chanute shale (Quivira), Loc. 6a. Gunnell coll. no. 3.

Genus PRIONIODUS Pander, 1856

PRIONIODUS DACTYLODUS Gunnell, n. sp.
Plate 31, figure 1

Bar strongly arching, bearing seven large denticles along oral surface. Small ridge crossing bar between largest two denticles. Cross-section of denticles sub-semicircular. Three largest denticles occupying about one-half of oral surface; rest of oral surface bearing four denticles. Smaller denticles curving toward convex side of specimen.

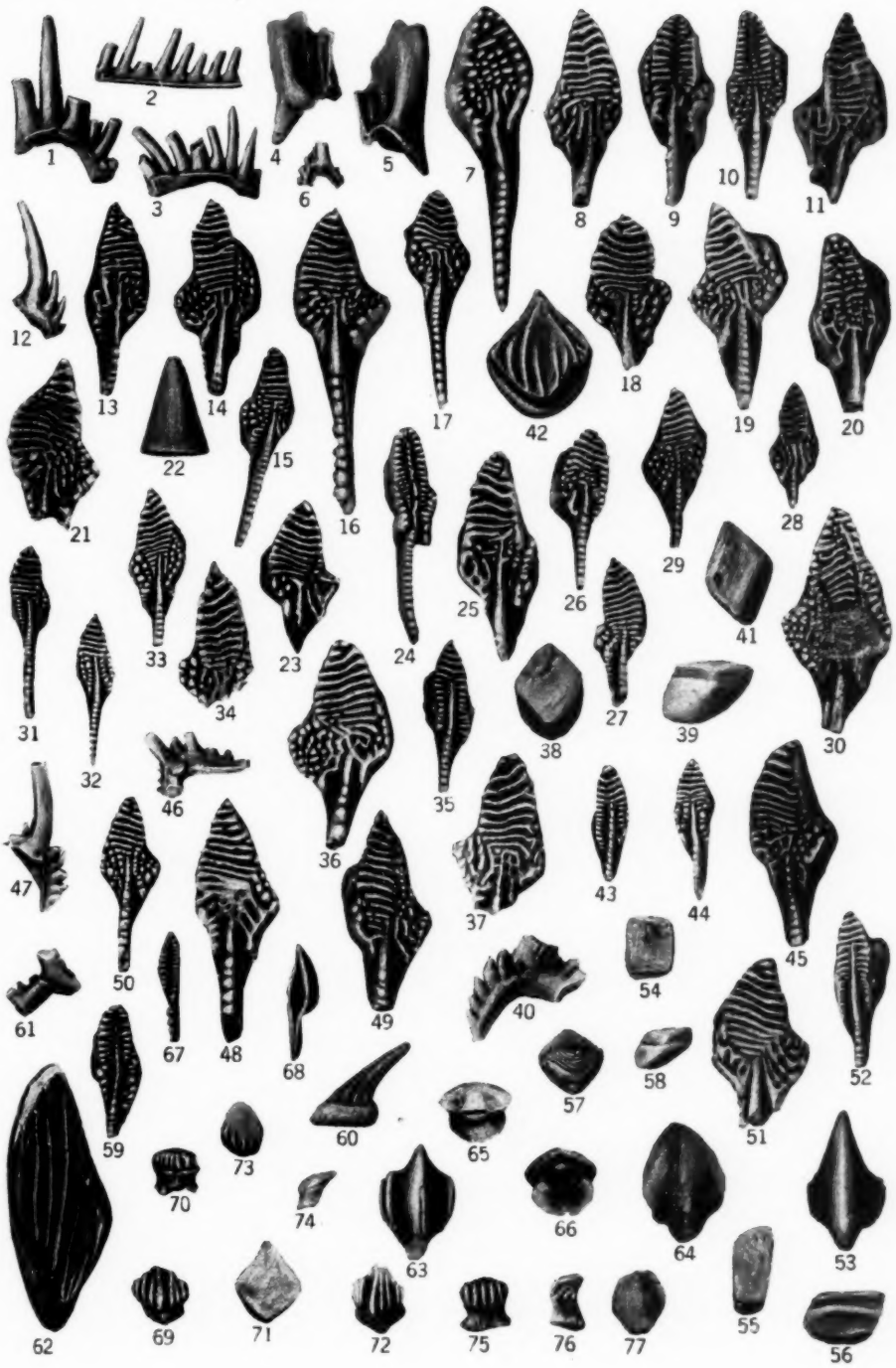
This species is distinguished by the uniform size of its denticles from *P. cacti*.

The smallest denticle, and a portion of the bar are broken from the

Explanation of Plate 31

Figs.

1—*Prioniodus dactylodus* Gunnell n. sp., ×20. Side view.
2—*Lonchodus simplex* ? Pander, ×20. Side view.
3—*Lonchodina* sp., ×20. Side view.
4, 5—*Prioniodus cacti* Gunnell, n. sp., ×20. Side views.
6—*Synprioniodina* sp., ×20. Posterior view.
7—*Idiognathodus fustiformis* Gunnell, n. sp., ×20. Oral view.
8—*Idiognathodus cuneiformis* Gunnell, n. sp., ×20. Oral view
9—*Streptognathodus clavatulus* Gunnell, n. sp., ×20. Oral view.
10—*Idiognathodus cancellosus* Gunnell, n. sp., ×20. Oral view.
11—*Idiognathodus harkeyi* Gunnell, n. sp., ×20. Oral view.
12—*Prioniodus* ? *galesburgensis* Gunnell, n. sp., ×20. Side view
13—*Idiognathodus jugosus* Gunnell, n. sp., ×20. Oral view.
14—*Idiognathodus siculus* Gunnell, n. sp., ×20. Oral view.
15—*Idiognathodus modulatus* Gunnell, n. sp., ×20. Oral view.
16—*Idiognathodus sulciferus* Gunnell, n. sp., ×20. Oral view.
17, 18—*Idiognathodus lobatus* Gunnell, n. sp., ×20. Oral views.
19—*Idiognathodus clavatus* Gunnell, n. sp., ×20. Oral view.
20—*Idiognathodus nodostriatus* Gunnell, n. sp., ×20. Oral view.
21—*Idiognathodus porcatus* Gunnell, n. sp., ×20. Oral view.
22—*Paleoniscus* sp., ×20. Side view.
23—*Idiognathodus chiriformis* Gunnell, n. sp., ×20. Oral view.
24—*Idiognathodus regulatus* Gunnell, n. sp., ×20. Oral view.
25—*Idiognathodus ruidus* Gunnell, n. sp., ×20. Oral view.
26—*Idiognathodus biconvexus* Gunnell, n. sp., ×20. Oral view.
27—*Idiognathodus liratus* Gunnell, n. sp., ×20. Oral view.
28—*Idiognathodus spathodus* Gunnell, n. sp., ×20. Oral view.
29—*Idiognathodus semipapulatus* Gunnell, n. sp., ×20. Oral view.
30—*Idiognathodus megistus* Gunnell n. sp., ×20 Oral view
31, 32—*Idiognathodus lanceolatus* Gunnell, n. sp., ×20. Oral views.
33—*Idiognathodus folium* Gunnell, n. sp., ×20. Oral view.
34—*Idiognathodus cicatricosus* Gunnell, n. sp., ×20. Oral view.
35—*Idiognathodus binodosus* Gunnell, n. sp., ×20. Oral view.
36—*Idiognathodus wintersetensis* Gunnell, n. sp., ×20. Oral view.
37—*Idiognathodus strigillatus* Gunnell, n. sp., ×20. Oral view.
38, 39—*Holmesella equilaterata* Gunnell, n. sp., ×20. Oral and side views.
40—*Bryantodus* ? sp., ×20. Side view.
41—*Holmesella parallelata* Gunnell, n. sp., ×20. Oral view.
42—*Holmesella ornata* Gunnell, n. sp., ×20. Oral view.
43—*Idiognathodus confragus* Gunnell. n. sp., ×20. Oral view.
44—*Idiognathodus gemmiformis* Gunnell, n. sp., ×20. Oral view.
45—*Idiognathodus vadosus* Gunnell, n. sp., ×20. Oral view.
46—*Hibbardella* ? sp., ×20. Side view.
47—*Idioprioniodus typus* Gunnell, n. sp., ×20. Side view.
48—*Idiognathodus erodus* Gunnell, n. sp., ×20. Oral view.
49—*Idiognathodus fusiformus* Gunnell, n. sp., ×20. Oral view.
50—*Idiognathodus semipapulatus*, n. sp., ×20. Oral view.
51—*Idiognathodus wintersetensis*, n. sp., ×20. Oral view.
52—*Idiognathodus cariniferus* Gunnell, n. sp., ×20. Oral view.
53—*Moreyella typicalis* Gunnell, n. sp., ×20. Oral view.
54—*Holmesella parallella* Gunnell, n. sp., ×20. Oral view.
55, 56—*Holmesella elongata* Gunnell, n. sp., ×20. Oral view, side view.
57, 58—*Holmesella equilaterata*, n. sp., ×20. Oral view, side view.
59—*Idiognathodus biliratus* Gunnell, n. sp., ×20. Oral view.
60—*Idiacanthus bellistriatus* Gunnell, n. sp., ×20. Side view.
61—*Hibbardella* sp., ×20. Side view.
62—Fish scale, ×20. Oral view.
63—*Moreyella aviculiformis* Gunnell, n. sp., ×20. Oral view.
64—*Cooleyella spatulata* Gunnell, n. sp., ×20. Oral view.
65, 66—*Cooleyella peculiaris* Gunnell, n. sp., ×20. Antero-oral and postero-aboral views.
67, 68—*Cavusgnathus lautus* Gunnell, n. sp., ×20. Oral and aboral views.
69—*Cooperella striatula* Gunnell, n. sp., ×20. Oral view.
70—*Cooperella selluliformis* Gunnell, n. sp., ×20. Anterior view.
71—*Holmesella rhomboidelis* Gunnell, n. sp., ×20. Oral view.
72—*Cooperella subsulcata* Gunnell, n. sp., ×20. Oral view.
73, 74, 75—*Cooperella eroda* Gunnell, n. sp., ×20. Oral, side, and aboral views.
76, 77—*Cooperella rectistriata* Gunnell, n. sp., ×20. Side and antero-oral views.



Gunnell, Pennsylvanian Conodonts

extremity near the small denticles of the figured specimen.

Cherokee shale, Loc. 1. Gunnell coll. no. 4.

PRIONIODUS CACTI Gunnell, n. sp.
Plate 31, figures 4, 5

Bar small, strongly arching, bearing main cusp at one extremity, and spatulate extension continuous with side of main cusp on rest of upper surface. Ribs on spatulate extension parallel with main cusp. Aboral surface concave below main cusp.

This species is distinguished by the large size of the main denticle from *P. dactylodus*.

The portion of the specimen opposite the main cusp is broken from the figured specimen.

Cherokee shale, Loc. 1. Gunnell coll. no. 5.

PRIONIODUS ? GALESBURGENSIS Gunnell, n. sp.
Plate 31, figure 12

Bar almost straight, bearing four denticles subcircular in cross-section, which gradually decrease in size from one end of bar to other. Denticles in one plane, and curving toward posterior extremity. Aboral surface concave below large denticle.

This species is distinguished by the posterior curvature of the main denticle from *P. cacti*.

Galesburg shale, Loc. 5a. Gunnell coll. no. 6.

PRIONIODUS sp.
Plate 32, figure 32

The aboral surface of this specimen is concave opposite the cusp.

Chanute shale (Quivira), Loc. 3a.

Genus SUBPRIONIODUS Smith, 1907

SUBPRIONIODUS sp.
Plate 32, figure 33

Chanute shale (Quivira), Loc. 3a.

SUBPRIONIODUS sp.
Plate 33, figure 19

This specimen somewhat resembles *S. paucidentatus* Smith.

Americus limestone, Loc. 7.

SUBPRIONIODUS sp.
Plate 33, figure 27

This specimen resembles one of the specimens figured as *S. paucidentatus* Smith.

Americus limestone, Loc. 7.

Family PRIONIODINIDAE Ulrich and Bassler, 1926

Genus BRYANTODUS Ulrich and Bassler, 1926

BRYANTODUS ? sp.
Plate 31, figure 40

Winterset limestone, Loc. 2b.

BRYANTODUS DELICATUS Gunnell, n. sp.
Plate 32, figure 43

Bar thin, slightly curving in one plane, sides parallel, and oral surface bearing nine denticles on each side of main cusp. Main cusp occupying space equal to that occupied by three dentricles. Anterior and posterior edges of denticles sharp. Two small flanges, one on each lateral side of minute elongate concavity, occur on aboral surface below main cusp.

This species is distinguished from *B. sulcatus* Stauffer and Plummer, by the greater length of the main cusp of the latter form. Although Stauffer and Plummer describe the longer part of the bar as the posterior portion the writer believes this repre-

sents the anterior part because of the relationship between conodonts and the teeth of cyclostomes.

Chanute shale (Quivira), Loc. 6a. Gunnell coll. no. 7.

BRYANTODUS RUGOSUS Gunnell, n. sp.
Plate 32, figure 44

Basal outline resembling integral sign. Bar high, thickest at base below cusp, and bearing denticles of different sizes together with cusp along upper surface; curving abruptly, slightly anterior to cusp, and about one-fourth total length posterior to cusp. Denticles confluent throughout most of their height, ten of which occur anterior to cusp. Upper edges of denticles spatulate. Pulp cavity on aboral surface deep, and extending throughout length of bar with greatest width opposite cusp.

The thick bar and irregular denticles distinguish this species from *B. strigatus*.

Chanute shale, (Quivira), Loc. 3a. Gunnell coll. no. 8.

BRYANTODUS STRIGATUS Gunnell, n. sp.
Plate 32, figure 45

Bar thin, slightly curving in one plane; sides expanding at base of denticles; oral surface with cusp, posterior to which occur denticles of different sizes, and anterior to which are twelve denticles. Cusp occupying space almost equal to space occupied by two denticles. Denticles confluent from slightly above base to mid-height. Anterior and posterior edges of denticles sharp. Two small flanges occur on aboral surface below cusp; one on each lateral margin of pulp cavity. Pulp cavity originating one-fourth total length of bar from anterior extremity, and extending to posterior end with greatest width and depth opposite cusp.

The main cusp is not twice the size of the largest denticle as is probably true of *B. delicatulus* Stauffer and Plummer.

Chanute shale (Quivira), Loc. 6a. Gunnell coll. no. 9.

BRYANTODUS STRIGILLATUS Gunnell, n. sp.
Plate 32, figure 46

Bar thin, sides slightly expanding at base of denticles; median and anterior portions gently curving, posterior section straight; height greatest near anterior end and gradually decreasing toward posterior end. Bar bearing cusp and denticles on oral surface. Anterior to cusp there are fourteen confluent denticles and posterior to cusp twelve denticles of different sizes. Pulp cavity on oral surface originating one-third total length of bar from anterior extremity, and extending to posterior end with greatest width and depth opposite cusp.

The species is distinguished by the greater number of denticles on the anterior portion of the bar from *B. strigatus*.

Chanute shale (Quivira), Loc. 6a. Gunnell coll. no. 10.

BRYANTODUS CAMERATUS Gunnell, n. sp.
Plate 32, figure 47

Bar thin, curving, and strongly developed below cusp. Oral surface with many long denticles of about equal size anterior to cusp, and few denticles from cusp to posterior ex-

tremity which decrease in size from cusp to posterior end. Denticles and cusp subelliptical in cross-section. Pulp cavity extending throughout total length of aboral surface. Aboral surface bearing flanges on each lateral margin; greatest width occuring below main cusp.

This species is distinguished by the long slender denticles from *B. delicatus*.

Chanute shale (Quivira), Loc. 6a. Gunnell coll. no. 11.

Genus EUPRIONIODINA Ulrich and Bassler, 1926

EUPRIONIODINA ? sp.
Plate 33, figure 6

Chanute shale (Quivira), Loc. 6a.

EUPRIONIODINA ? sp.
Plate 33, figure 24

Americus limestone, Loc. 7.

Genus HIBBARDELLA Ulrich and Bassler, 1926

HIBBARDELLA ? sp.
Plate 31, figure 46

Although apparently bilaterally symmetrical, and consisting of large, central, main cusp with smaller denticles along the bar on each side of the cusp, one cannot be sure that this specimen belongs to *Hibbardella*, because a portion of the bar is missing.

Winterset limestone, Loc. 2c.

HIBBARDELLA sp.
Plate 31, figure 61

Winterset limestone, Loc. 2d.

Genus HINDEODELLA Ulrich and Bassler, 1926

HINDEODELLA sp.
Plate 32, figure 34

Chanute shale (Quivira), Loc. 3a.

Genus LONCHODINA Ulrich and Bassler, 1926

LONCHODINA sp.
Plate 31, figure 3

Cherokee shale, Loc. 1.

LONCHODINA ? sp.
Plate 32, figure 40

Chanute shale (Quivira), Loc. 3a.

LONCHODINA ? sp.
Plate 32, figure 41

Chanute shale (Quivira), Loc. 3a.

LONCHODINA ? sp.
Plate 32, figure 42

Chanute shale (Quivira), Loc. 3a.

Genus LONCHODUS Pander, 1856

LONCHODUS SIMPLEX? Pander
Plate 1, figure 2

Lonchodus simplex PANDER, *1856*, Monographie der fossilen Fishe des Silurischen Systems der russisch—baltischen Gouvernement, p. 31, tab. 2A, figs. 2, 3, 5, 6.

Cherokee shale, Loc. 1.

LONCHODUS sp.
Plate 32, figure 38

Chanute shale (Quivira), Loc. 6a.

Genus SYNPRIONIODINA Ulrich and Bassler, 1926

SYNPRIONIODINA sp.
Plate 31, figure 6

Cherokee shale, Loc. 1.

Family POLYGNATHIDAE Ulrich and Bassler, 1926

Genus IDIOGNATHODUS Gunnell, 1931

IDIOGNATHODUS FUSTIFORMIS Gunnell, n. sp.
Plate 31, figure 7

Oral surface bearing elongate nodes. Margins of oral surface oval in cross-section. One side of plate curving symmetrically in anterior posterior

direction, other side of plate slightly lobate at posterior end. Anterior end sharp. Bar strong at union with plate, and gradually thinning toward posterior extremity.

The nodose oral-surface distinguishes this species from *I. claviformis* Gunnell 1931.

Cherokee shale, Loc. 1. Gunnell coll. no. 12.

IDIOGNATHODUS CUNEIFORMIS
Gunnell, n. sp.
Plate 31, figure 8

Posterior oral surface of plate with four small, longitudinal ridges occupying central portion, whereas irregularly arranged nodes occupy right and left areas; rest of oral surface with eleven transverse parallel ridges of which four successive ones occur immediately posterior to anterior four, and connect medianly by small longitudinal ridge. Sides of plate almost vertical. Left posterior side lobate. Anterior end sharp. A large portion of the bar is broken from the figured specimen.

The less expanded lobe distintinguishes this species from *I. magnificus*, Stauffer and Plummer.

Galesburg shale, Loc. 5a. Gunnell coll. no. 13.

IDIOGNATHODUS CANCELLOSUS
Gunnell, n. sp.
Plate 31, figure 10

Carina separating right from left, nodose, postero-oral surfaces, anterior to which occur three undulating transverse parallel ridges. Anterior oral surface bearing two parallel grooves between which occur row of about nine nodes. Right oral margin bearing seven transverse ridges. Left oral margin surmounted by about nine transverse ridges. Lobe on right side of plate elongate, and bearing row of nodes on oral surface. Sides of plate almost vertical; basal part of right side with flange.

The median longitudinal row of nodes on the oral surface distinguishes this species from *I. cuneiformis*.

Galesburg shale, Loc. 5a. Gunnell coll. no. 14.

IDIOGNATHODUS HARKEYI Gunnell, n. sp.
Plate 31, figure 11

Linguiform part of oral surface bearing 12 transverse ridges. Oral surface of left posterior lobe surmounted by sinuous interlocking ridges. Oral surface of right posterior lobe bearing irregularly arranged nodes. Anterior end sharp. Sides of plate almost vertical; basal part of right side bearing flange.

The reticulate postero-oral surface distinguishes this species from *I. cuneiformis*.

Galesburg shale, Loc. 5a. Gunnell coll. no. 15.

IDIOGNATHODUS JUGOSUS Gunnell, n. sp.
Plate 31, figure 13

Posterior oral surface of plate bearing carina on median portion with few nodes on right area; left area bearing two transverse ridges posterior to which occur longitudinal row of nodes extending over lobate area. Linguiform part of oral surface bearing numerous discontinuous transverse ridges. Sides slightly inflated at mid-height. Anterior end sharp.

The broken ridges on the oral sur-

face distinguish this species from *I. cuneiformis*.

Galesburg shale, Loc. 5a. Gunnell coll. no. 16.

IDIOGNATHODUS SICULUS Gunnell, n. sp.
Plate 31, figure 14

Oral surface of plate bearing 13 transverse ridges on spatulate portion, central one of which bifurcates at right side of plate; large, elongate, right lobe bearing numerous nodes, some of which coalesce forming ridges; area of left lateral lobe with small nodes, and ridges. Anterior part of carina bifurcating near posterior transverse ridge. Anterior end sharp.

The bladelike outline of this form distinguishes it from *I. harkyi*.

Galesburg shale, Loc. 5a. Gunnell coll. no. 17.

IDIOGNATHODUS MODULATUS Gunnell, n. sp.
Plate 31, figure 15

Oral surface of plate bearing about eight transverse ridges on linguiform area with nodes on right, and left lobes. Length of plate equal to length of bar. Small flange on left, basal side of plate. Anterior end blunt.

The continuous ridges on the antero-oral surface distinguishes this species from *I. cancellosus*.

Galesburg shale, Loc. 5a. Gunnell coll. 18.

IDIOGNATHODUS SULCIFERUS
Gunnell, n. sp.
Plate 31, figure 16

Anterior oral surface of plate with 11 transverse ridges; continuity of two posterior ridges broken. Right and left posterior portions of oral surface bearing nodes which in places coalesce to form ridges. Right lobe extending laterally with almost right angle outline formed by two sides. Anterior end sharp, and in straight line with denticles on bar. Sides slightly inflated.

The sharp anterior point distinguishes this species from *I. modulatus*.

Galesburg shale, Loc. 5a. Gunnell coll. no. 19.

IDIOGNATHODUS LOBATUS Gunnell, n. sp.
Plate 31, figures 17, 18

Linguiform part of plate oral surface bearing about nine transverse ridges. Longitudinal ridges, bearing nodes in places, occur on postero-oral surface of plate opposite sides of carinal ridge. Right and left lobate posterior parts of plate bearing nodes on oral surface. Sides of plate almost vertical; basal portion of left side with flange. Bar strong.

The lenticular outline around the oral ridges distinguishes this species from *I. sulciferus*.

The specimen represented by figure 18 is probably an old form of the species in which the nodes, and lobes are well developed.

Galesburg shale, Loc. 5a. Gunnell coll. no. 20.

IDIOGNATHODUS CLAVATUS Gunnell, n. sp.
Plate 31, figure 19

Spatulate part of plate oral surface bearing about ten dissected, transverse ridges. Between right and left nodose, lobate parts of oral surface occur three longitudinal ridges, median ridge continuous with carina, and coalescing with side of ridge on right, forming X pattern. Median line curving to left. Basal part of right side with flange. Anterior end sharp.

The greater number of transverse ridges on *I. siculus* distinguishes it from this species.

Galesburg shale, Loc. 5a. Gunnell coll. no. 21.

IDIOGNATHODUS NODOSTRIATUS
Gunnell, n. sp.
Plate 31, figure 20

Each postero-oral margin of plate bearing ridge; rest of oral surface with nodes, and ridges, most of which trend in transverse direction. Oral margins oval in cross-section. Flange occurring on basal, right side of plate. Anterior end blunt.

The greater number of ridges on the oral surface distinguishes this species from *I. fustiformis*.

Galesburg shale, Loc. 5a. Gunnell coll. no. 22.

IDIOGNATHODUS PORCATUS Gunnell, n. sp.
Plate 31, figure 21

Oral surface of plate bearing 12 transverse ridges on anterior portion; area of right postero-lateral lobe bearing many nodes, and small ridges; area to left of carinal ridge bearing few nodes. Anterior end dull. Outline of right lobe subangular. Sides of plate almost vertical.

The curved anterior end distinguishes this species from *I. lobatus*.

Galesburg shale, Loc. 5a. Gunnell coll. no. 23.

IDIOGNATHODUS CHIRIFORMIS
Gunnell, n. sp.
Plate 31, figure 23

Spatulate portion of plate oral surface bearing ten transverse ridges with node occurring near right extremity of each four posterior ridges. Right posterior lobe bearing ridges on oral surface. Posterior oral surface of plate bearing nodes to left of carinal ridge. Sides almost vertical. Anterior end sharp.

The subtriangular outline around the transverse oral ridges distinguishes this species from *I. lobatus*.

Galesburg shale, Loc. 2a. Gunnell coll. no. 24.

IDIOGNATHODUS RUGULATUS Gunnell, n. sp.
Plate 31, figure 24

Oral surface of plate bearing furrow on each side of median row of nodes; rest of oral surface with nodes, and transverse ridges. Small postero-lateral lobes on right, and left sides of plate. Sides of plate almost vertical, basal portions bearing flanges on right and left sides. Anterior end blunt. Bar thin, and slightly curving.

The smaller lobes distinguish this species from *I. cancellosus*.

Galesburg shale, Loc. 2a. Gunnell coll. no. 25.

IDIOGNATHODUS RUIDUS Gunnell, n. sp.
Plate 31, figure 25

Oral surface of plate bearing eight transverse ridges, with node on left oral margin between extremities of fourth, and fifth ridges; posterior part bearing reticulate covering except nodose area opposite sides of carinal ridge. Left antero-lateral oral margin serrate in outline; rest of oral margins oval in outline. Small flange on basal part of left side. Anterior end dull.

The continuous ridges on the oral surface distinguishes this species from *I. nodostriatus*.

Galesburg shale, Loc. 2a. Gunnell coll. no. 26.

IDIOGNATHODUS BICONVEXUS Gunnell, n. sp.
Plate 31, figure 26

Oral surface of plate bearing transverse ridges on anterior portion, and irregularly shaped nodes with hook-like carinal ridge on posterior area; outline biconvex. Left side of plate bearing flange on basal margin.

The biconvex outline distinguishes this species from *I. liratus*.

Galesburg shale, Loc. 2a. Gunnell coll. no. 27.

IDIOGNATHODUS LIRATUS Gunnell, n. sp.
Plate 31, figure 27

Plate oral surface bearing 11 transverse ridges on anterior portion, and each postero-lateral part with row of nodes between which occurs carinal ridge. Left postero-lateral lobe bearing few large nodes on oral surface. Flange on basal right side of plate.

The absence of small nodes on the oral surface opposite the lobe distinguishes this species from *I. magnificus* Stauffer and Plummer.

Galesburg shale, Loc. 2a. Gunnell coll. no. 28.

IDIOGNATHODUS SPATHODUS Gunnell, n. sp.
Plate 31, figure 28

Oral surface of plate bearing nine transverse ridges on spatulate portion, posterior to which occur three longitudinal ridges. Nodes occur on oral surface of right, and left postero-lateral lobes. Sides of plate almost vertical. Anterior end sharp.

The greater number of transverse ridges on *I. liratus* distinguishes it from this form.

Winterset limestone, Loc. 5b. Gunnell coll. no. 29.

IDIOGNATHODUS SEMIPAPULATUS
Gunnell, n. sp.
Plate 31, figure 29

Oral surface of plate with nine transverse ridges on spatulate part; rest of area bearing numerous nodes. Each side of plate bearing small flange on basal part. Anterior end sharp.

The large number of nodes on the postero-oral surface distinguishes this species from *I. spathodus*.

Winterset limestone, Loc. 5b. Gunnell coll. no. 30.

IDIOGNATHODUS MEGISTUS Gunnell, n. sp.
Plate 31, figure 30

Oral surface of plate bearing eight transverse ridges on linguiform portion; nodes and ridges occur on anterior, and lateral areas; postero-central part smooth; small nodes occur on lobate postero-lateral area. Right oral margin bearing nodes. Sides oval in cross-section. Anterior end dull.

The numerous nodes on the oral margins of the plate distinguish this species from *I wintersetensis*,

Winterset limestone, Loc. 5b. Gunnell coll. no. 31.

IDIOGNATHODUS LANCEOLATUS
Gunnell, n. sp.
Plate 31, figures 31, 32

Oral surface of plate bearing seven transverse ridges on linguiform portion; posterior part with carinal ridge, and rows of nodes. Sides almost vertical. Anterior end sharp.

The small number of transverse ridges distinguishes this species from *I. liratus*.

On the specimen represented by

figure 31 it appears that there exist rudiments of another postero-lateral row of nodes.

Winterset limestone, Loc. 5b. Gunnell coll. no. 32.

IDIOGNATHODUS FOLIUM Gunnell, n. sp.
Plate 31, figure 33

General shape leaflike. Oral surface of plate bearing 11 transverse ridges, anterior to anterior extremity of carinal ridge; two rows of transversely elongate ridges opposite each side of carinal ridge; nodes on each postero-lateral lobe. Sides of plate almost vertical; right side with small flange on median basal portion. Anterior end sharp.

The greater number of transverse ridges and fewer nodes distinguish this species from *I. semipapulatus*.

Winterset limestone, Loc. 5b. Gunnell coll. no. 33.

IDIOGNATHODUS CICATRICOSUS
Gunnell, n. sp.
Plate 31, figure 34

Linguiform part of plate oral surface bearing nine transverse ridges which bifurcate or become lobate from median line toward extremities; few nodes on anterior area. Left postero-lateral lobe sub-semicircular in outline; oral surface nodose. Postero-median portion of oral surface reticulate. Right postero-lateral lobe elongate; oral surface nodose. Anterior end sharp. Sides almost vertical.

The sharp anterior end distinguishes this species from *I. strigillatus*.

Winterset limestone, Loc. 5b. Gunnell coll. no. 34.

IDIOGNATHODUS BINODOSUS Gunnell, n. sp.
Plate 31, figure 35

General shape lanceolate. Plate longitudinally arching; oral surface bearing transverse ridges, majority being cut by anterior extension of carinal ridge; anterior to carinal ridge occur five or six transverse ridges. Right side of plate almost vertical with nodose region on upper submedian surface. Left side of plate extending outward at base; upper submedian surface nodose. Anterior end sharp.

A single node on either side of the plate distinguishes this species from *I. lanceolatus*.

Winterset limestone, Loc. 2f. Gunnell coll. no. 34.

IDIOGNATHODUS WINTERSETENSIS
Gunnell, n. sp.
Plate 31, figure 36

General shape chiriform. Plate high, wide, and longitudinally arching; oral surface with 10 transverse ridges on linguiform portion; nodes on large, lobate, left area; rest of surface reniform. Oral margins oval in cross-section.

The larger lobe distinguishes this species from *I. ruidus*.

Winterset limestone, Loc. 5b. Gunnell coll. no. 35.

IDIOGNATHODUS STRIGILLATUS
Gunnell, n. sp.
Plate 31, figure 37

General shape chiriform. Plate high, longitudinally arching; oral surface bearing nine transverse ridges which bifurcate or become lobate from median line toward extremities of linguiform area; node on left pos-

tero-lateral lobe to right of which occurs reticulate area. Sides of plate almost vertical with flange on basal part of right side.

The larger lobate area of *I. wintersetensis* distinguishes it from this species.

Winterset limestone, Loc. 5b. Gunnell coll. no. 36.

IDIOGNATHODUS CONFRAGUS Gunnell, n. sp.
Plate 31, figure 43

General shape lanceolate. Oral surface of plate bearing five transverse ridges, anterior to anterior extremity of carinal ridge; row of nodes on each postero-lateral margin, between which occurs carinal ridge. Small lobe on right side of plate bearing one node. Sides of plate almost vertical.

The greater number of transverse ridges anterior to anterior extremity of carinal ridge on *I. gemmiformis* distinguishes it from this species.

Winterset limestone, Loc. 2c. Gunnell coll. no. 37.

IDIOGNATHODUS GEMMIFORMIS
Gunnell n. sp.
Plate 31, figure 44

General shape budlike. Oral surface of plate with six transverse ridges, anterior to anterior extremity of carinal ridge; three nodes on anterior tip, and rows of nodes on each side of carinal ridge. Anterior end dull. Sides of plate almost vertical with small flange on median basal portion of right side.

The greater number of unbroken transverse ridges distinguishes this species from *I. confragus*.

Winterset limestone, Loc. 2c. Gunnell coll. no. 38.

IDIOGNATHODUS VADOSUS Gunnell, n. sp.
Plate 31, figure 45

General shape claviform. Oral surface of plate bearing nine transverse ridges on spatulate part, posterior to which occur reticulate, and nodose areas; node and high postero-lateral ridge occupy area of right postero-lateral lobe; nodose carinal ridge extending short distance anteriorly on posterior area. Summit of oral margins slightly higher than rest of plate surface. Right oral margin broad, nodose, and sloping gently toward right side, Outline of left oral margin serrate. Right side of plate oval in cross-section with maximum inflation about mid-height. Left side of plate almost vertical.

The broad sloping right oral margin distinguishes this species from *I. strigillatus*.

Winterset limestone, Loc. 2b. Gunnell coll. no. 39.

IDIOGNATHODUS ERODUS Gunnell, n. sp.
Plate 31, figure 48

General shape sublanceolate. Oral surface of plate with nine transverse ridges on anterior portion; posterior portion reniform; antero-lateral lobate area nodose. Right antero-lateral oral margins oval in cross-section. Left antero-lateral margin serrate in outline. Sides of plate almost vertical with large flange on basal portion of left side. Anterior end sharp. The reniform area of the oral surface shows evidence of wear.

This species has larger and fewer transverse ridges than does *I. fusiformus*.

Winterset limestone, Loc. 2d. Gunnell coll. no. 40.

IDIOGNATHODUS FUSIFORMUS
Gunnell, n. sp.
Plate 31, figure 49

General shape sublanceolate. Oral surface of plate with row of nodes on right antero-lateral margin, to right of which occur 10 transverse ridges; posterior, and lobate areas bearing nodes, and sinuous ridges. Sides almost vertical with flange on basal portion of left side. Anterior end sharp.

The smaller and greater number of transverse ridges distinguishes this species from *I. erodus*.

Winterset limestone, Loc. 2e. Gunnell coll. no. 41.

IDIOGNATHODUS CARINIFERUS
Gunnell, n. sp.
Plate 31, figure 52

General shape subfusiform. Oral surface of plate with five transverse ridges anterior to anterior extremity of carinal ridge. Left side of plate almost vertical. Right side of plate extending laterally from oral margins toward base, forming large flange with oval outline; single denticle on upper margin. Carinal ridge long, and straight. If the specimen is examined without a sublimate covering the carinal ridge appears to have a greater anterior extension than exists.

The greater length of the carina distinguishes this species from *I. gemmiformis*.

Winterset limestone, Loc. 2e. Gunnell coll. no. 42.

IDIOGNATHODUS SEMIPAPULATUS, n. sp.
Plate 31, figure 50

Winterset limestone, Loc. 2e.

IDIOGNATHODUS WINTERSETENSIS, n. sp.
Plate 31, figure 51

The postero-oral surface of these specimens show evidences of wear.

Winterset limestone, Loc. 2d.

IDIOGNATHODUS BILIRATUS Gunnell, n. sp.
Plate 31, figure 59

General shape fusiform. Oral surface of plate with two longitudinal furrows converging anteriorly, between which occurs long, nodose, carinal ridge. Nodes of different sizes occur uniformly on all oral margins. Anterior end oval in outline. Sides of plate almost vertical with flange occurring on basal part of left side.

The absence of transverse ridges extending across the plate distinguishes this species from *I. carinifierus*. This species is referred to the genus *Idiognathodus* rather than *Streptognathodus* Stauffer and Plummer, because the oral surface is not completely traversed by the median groove (axial furrow).

Winterset limestone, Loc. 2f. Gunnel coll. no. 43.

IDIOGNATHODUS SYMMETRICUS
Gunnell, n. sp.
Plate 32, figure 3

Plate sublanceolate in shape; oral surface bearing few short transverse ridges on anterior area, and nodose longitudinal ridges on posterior area, longest of latter being carinal ridge. Outline of oral margins serrate. Antero-lateral sides of plate similar in length, and appearance. Height of plate unusually small. Plate longitudinal straight.

The serrate outline distinguishes this species from *I. rotundus*.

Cherryvale shale (Fontana), Loc. 4a. Gunnell coll. no. 44.

IDIOGNATHODUS ROTUNDUS Gunnell, n. sp.
Plate 32, figure 4

Plate claviform in shape; oral surface with about seven transverse ridges anterior to anterior end of carinal ridge, and nodes set off from rest of surface by curving ridge, occur on left postero-lobate area. Oral margins nodose; cross-section oval. Anterior part of plate outline semicircular.

The semicircular outline of the anterior end of the plate distinguishes this species from *I. symmetricus*.

Cherryvale shale (Fontana), Loc. 4a. Gunnell coll. no. 45.

IDIOGNATHODUS CHERRYVALENSIS Gunnell, n. sp.
Plate 32, figure 5

Oral surface of plate bearing row of nodes opposite each side of carinal ridge anterior to which occur transverse ridges. Nodose carinal ridge extending medianly throughout posterior half of plate length. Basal antero-lateral part of plate left side bearing flange. Anterior end blunt.

The lack of long transverse ridges distinguishes this species from *I. rotundus*. As the median groove or the oral surface does not extend to the anterior end of the plate the generic reference is correct.

Cherryvale shale (Fontana), Loc. 4a. Gunnell coll. no. 46.

IDIOGNATHODUS CORRUGATUS Gunnell, n. sp.
Plate 32, figures 6, 7

Spatulate part of oral surface bearing 12 transverse ridges. Posterior oral surface with nodes on right lobe and left part of surface, between these areas occur three longitudinal ridges. Sides of plate almost vertical with large basal flange on left side. Anterior end sharp.

The greater number of transverse ridges distinguishes this species from *I. strigillatus*.

Cherryvale shale (Fontana), Loc. 4a. Gunnell coll. no. 47.

IDIOGNATHODUS STRIGILLATUS, n. sp.
Plate 32, figure 8

This specimen is the same species as that figured on plate 31, figure 37, but probably represents a younger specimen of a later age.

Cherryvale shale (Fontana), Loc. 4a.

IDIOGNATHODUS WALTERI Gunnell, n. sp.
Plate 32, figure 9

Spatulate part of oral surface bearing about 13 transverse ridges, anterior five or six being sinuous; right oral margin surmounted by ridge; oval in cross-section. Right posterior lobe of plate small; bearing ridges on oral surface. Left posterior lobe of plate bearing ridge on postero-lateral margin, and numerous nodes on rest of oral surface. Carinal ridge on oral surface between lobate areas. Sides of plate almost vertical. Anterior end oval in outline.

The blunt anterior end distinguishes this species from *I. corrugatus*.

Cherryvale shale (Fontana), Loc. 4a. Gunnell coll. no. 48.

IDIOGNATHODUS SIMPLEX Gunnell, n. sp.
Plate 32, figure 19

General shape sublanceolate. Plate oral surface with six transverse ridges

anterior to anterior end of carinal ridge, and row of transversely elongate ridges opposite each side of carinal ridge. Lateral lobate sides of plate small, bearing few nodes on oral surface. Carinal ridge extending throughout posterior half of plate total length. Greatest width extending through lobate areas. Length of right side of plate slightly greater

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EXPLANATION OF PLATE 32

FIGS. 1, 2—*Streptognathodus holmesi* Gunnell, n. sp., ×25. Oral view, side view.
3—*Idiognathodus symmetricus* Gunnell, n. sp., ×25. Oral view.
4—*Idiognathodus rotundus* Gunnell, n. sp., ×25. Oral view.
5—*Idiognathodus cherryvalensis* Gunnell, n. sp., ×25. Oral view.
6, 7—*Idiognathodus corrugatus* Gunnell, n. sp., ×25. Oral and side views.
8—*Idiognathodus strigillatus*, n. sp., ×25. Oral and side views.
9—*Idiognathodus walteri* Gunnell, n. sp., ×25. Oral view.
10—*Streptognathodus sulcatus* Gunnell, n. sp., ×25. Oral view.
11—*Streptognathodus multinodosus* Gunnell, n. sp., ×25. Oral view.
12—*Streptognathodus sulciferus* Gunnell, n. sp., ×25. Oral view.
13—*Streptognathodus corrugatus* Gunnell, n. sp., ×25. Oral view.
14—*Streptognathodus spatulatus* Gunnell, n. sp., ×25. Oral view.
15—*Paleoniscus* sp., ×25. Side view.
16—*Streptognathodus subdivisus* Gunnell, n. sp., ×25. Oral view.
17—*Streptognathodus ruidus* Gunnell, n. sp., ×25. Oral view.
18—*Streptognathodus rugosus* Gunnell, n. sp., ×25. Oral view.
19—*Idiognathodus simplex* Gunnell, n. sp., ×25. Oral view.
20—*Cooperella*, sp., ×25. Oral view.
21—*Williamsella typicalis* Gunnell, n. sp., ×25. Oral view.
22—*Cooleyella cuspidata* Gunnell, n. sp., ×25. Oral view.
23—*Cooleyella quadrilobata* Gunnell, n. sp., ×25. Oral view.
24—*Moreyella trilobata* Gunnell, n. sp., ×25. Oral view.
25—*Williamsella* ? sp., ×25. Oral view.
26—*Cooperella* ? sp., ×25. Antero-side view.
27—*Cooperella typicalis* Gunnell, n. sp., ×25. Oral view.
28—*Petrodus* ? sp., ×25. Oral view.
29—*Idiacanthus cameratus* Gunnell, n. sp., ×25. Side view.
30—*Idioprioniodus camurus* Gunnell, n. sp., ×25. Side view.
31—*Paleoniscus* sp., ×25. Side view.
32—*Prioniodus* sp., ×25. Side view.
33—*Subprioniodus* sp., ×25. Side view.
34—*Hindeodella* sp., ×25. Side view.
35—*Fortscottella gemmicula* Gunnell, n. sp., ×25. Antero-side view.
36, 37—*Idioprioniadus striatus* Gunnell, n. sp., ×25. Side views.
38—*Lonchodus* sp., ×25. Side views.
39—Fish tooth ?, ×25. Posterior view.
40—*Lonchodina* ? sp., ×25. Side view.
41—*Lonchodina* ? sp., ×25. Side view.
42—*Lonchodina* ? sp., ×25. Side view.
43—*Bryantodus delicatus* Gunnell, n. sp., ×25. Side view.
44—*Bryantodus rugosus* Gunnell, n. sp., ×25. Side view.
45—*Bryantodus strigatus* Gunnell, n. sp., ×25. Side view.
46—*Bryantodus strigillatus* Gunnell, n. sp., ×25. Side view.
47—*Bryantodus cameratus* Gunnell, n. sp., ×25. Side view.
48, 49, 50—*Gondolella merrilli* Gunnell, n. sp., ×25. Oral, side, and aboral views.
51, 52—*Gondolella lingulata* Gunnell, n. sp., ×25. Oral and side views.
53, 54, 55—*Gondolella sublanceolata* Gunnell, n. sp., ×25. Oral, aboral, and side views.
56, 57, 58—*Gondolella sinuata* Gunnell, n. sp., ×25. Oral, side, and aboral views.
59, 60, 61—*Idiognathodus warei* Gunnell, n. sp., ×25. Oral, aboral, and side views.
62, 63, 64—*Idiognathodus kansensis* Gunnell, n. sp., ×25. Oral, aboral and side views.
65—*Streptognathodus minutus* Gunnell, n. sp., ×25. Oral and side views.
66, 67, 68—*Streptognathodus chanutensis* Gunnell, n. sp., ×25. Oral, aboral, and side view

Gunnell, Pennsylvanian conodonts

than that of left side. Outline of oral surface scallop-like. Anterior end rather sharp.

This species has one less transverse ridge on the oral surface of the plate than *I. lanceolatus*, n. sp.

Cherryvale shale, Loc. 4d. Gunnell coll. no. 49.

IDIOGNATHODUS WAREI Gunnell, n. sp.
Plate 32, figures 59, 60, 61

Oral surface of plate bearing single node on anterior end, posterior to which occur nine transverse ridges; right and left areas opposite sides of carinal ridge bearing nodes, some of which coalesce to form ridges. Postero-lateral sides of plate lobate. Flanges occur on basal portion of plate sides.

The greater number of transverse ridges distinguishes *I. kansensis* from this form.

The specimens figured represent right and left varieties.

Chanute shale (Quivira), Loc. 3a. Gunnell coll. no. 50, 51, 52.

IDIOGNATHODUS KANSENSIS
Gunnell, n. sp.
Plate 32, figures 62, 63, 64

Oral surface of plate bearing single node on anterior end posterior to which occur 11 transverse ridges; area to right of carinal ridge with sinuous ridges; left lobate area bearing nodes on anterior part, and sinuous ridges on posterior portion. Flanges on basal portion of plate sides. Anterior end sharp.

The greater number of transverse ridges distinguishes this species from *I. warei.*

Chanute shale (Quivira), Loc. 3a. Gunnell coll. no. 53, 54, 55.

IDIOGNATHODUS FARRELLI Gunnell, n. sp.
Plate 33, figure 4

Anterior half of plate curving toward left side. Length to width ratio of oral surface 8 to 3. Oral surface bearing two nodes on anterior end and three transverse ridges anterior to anterior extremity of carinal ridge, with nodes, and ridges opposite each side of carinal ridge. Carinal ridge extending from bar medianly to five-eighths total length of plate. Flanges occur on basal portions of plate sides.

The unbroken transverse ridges on the antero-oral surface distinguishes this species from *I. multinodosus.*

Chanute shale (Quivira), Loc. 6a. Gunnell coll. no. 56.

IDIOGNATHODUS MULTINODOSUS
Gunnell, n. sp.
Plate 33, figure 5

Anterior half of plate curving toward left side. Oral surface length to width ratio 3 to 1. Oral surface nodose; carinal ridge extending anteriorly from bar to five-ninths total length of plate, anterior to which occur four transverse ridges; nodes occur on rest of oral surface. Lobate area on left side of plate bearing single node. Flanges occur on basal portions of plate sides.

The numerous nodes on the oral surface distinguishes this species from *I. farrelli.*

Chanute shale (Quivira), Loc. 6a. Gunnell coll. 57.

Genus STREPTOGNATHODUS
Stauffer and Plummer, 1932

Plate sublanceolate to claviform, and connected posteriorly to denticle-bearing bar. Oral surface with longitudinal, median groove on each side of which occur nodes or ridges. Aboral surface of plate concave; longitudinal groove separating two subequal areas.

STREPTOGNATHODUS CLAVATULUS
Gunnell, n. sp.
Plate 31, figure 9

Posterior oral surface of plate with two parallel, longitudinal grooves separating three irregular ridges. Right and left anterior areas of oral surface each bearing about 12 transverse ridges. Left marginal lobe elongate, and bearing row of nodes. Right marginal lobe bearing two to four nodes. Anterior end blunt. Bar thin, and bearing angular in outline denticles.

The blunt anterior end distinguishes this species from *S. excellsus* Stauffer and Plummer.

Galesburg shale, Loc. 5a. Gunnell coll. no. 58.

STREPTOGNATHODUS HOLMESI
Gunnell, n. sp.
Plate 32, figures 1, 2

Plate sublanceolate; oral surface with row of small transverse ridges on each side of median groove. Posterior half of median groove occupied by carinal ridge. Right side of plate longitudinally lobate with few nodes on oral surface. Left side of plate with basal flange. Denticles on bar rather uniform in size and shape.

The anterior extension of the carina distinguishes this species from *S. gracilis* Stauffer and Plummer.

Cherryvale shale (Fontana), Loc. 4a. Gunnell coll. no. 59.

STREPTOGNATHODUS SULCATUS
Gunnell, n. sp.
Plate 32, figure 10

Oral surface of plate with greatest width about one-fourth the total length of plate from anterior end; transverse ridges on each side of median groove on anterior portion; nodes on each postero-lateral margin. Carinal ridge occupying median groove from slightly in front of mid-length of plate to bar. Sides of plate slightly inflated near mid-length. Lateral margins of oral surface serrate near anterior end.

The greatest width of the plate being near the anterior end distinguishes this species from *S. holmesi.*

Cherryvale shale (Fontana), Loc. 4a. Gunnell coll. no. 60.

STREPTOGNATHODUS MULTINODOSUS
Gunnell, n. sp.
Plate 32, figure 11

Oral surface of plate bearing row of transversely elongate nodes on each side of median groove. Median groove rather broad, and shallow. Right postero-lateral margin bearing second row of few nodes. Lobate, left side of plate bearing six or seven nodes on aboral surface. Carinal ridge occupying posterior half of median groove. Sides of plate almost vertical; right side about nine-tenths the length of left side. Anterior end sharp.

The presence of a lobate area distinguishes this from *S. sulcatus.*

Cherryvale shale (Fontana), Loc. 4a. Gunnel coll. no. 61.

STREPTOGNATHODUS SULCIFERUS
Gunnell, n. sp.
Plate 32, figure 12

Plate oral surface with row of transverse ridges on each side of median groove; ridges biconvex in outline; left lobate area with nodes. Carinal ridge occupying posterior one-third of total length of median groove. Outline of antero-lateral oral margins scallop-like. Sides of plate almost vertical, and bearing basal flanges. Length of left side of plate slightly longer than that of right side. Bar joining plate at obtuse angle.

The rather uniform length of either side of the plate distinguishes this species from *S. multinodosus*.

Cherryvale shale (Fontana), Loc. 4a. Gunnell coll. no. 62.

STREPTOGNATHODUS CORRUGATUS
Gunnell, n. sp.
Plate 32, figure 13

Plate oral surface with row of small, transverse ridges on each side of anterior portion of median groove opposite sides of nodose carinal ridge. Carinal ridge occupying slightly more than posterior half of median groove. Left posterior part of plate oral surface bearing two or three nodes. Anterior end blunt. Denticles on bar round in cross-section. Plate curving toward left side. Sides of plate of about equal length.

The left curvature of the plate distinguishes this species from *S. sulciferus*.

Cherryvale shale (Fontana), Loc. 4a. Gunnell coll. no. 64.

STREPTOGNATHODUS SPATULATUS
Gunnell, n. sp.
Plate 32, figure 14

Plate oral surface with row of small, transverse ridges on each side of median groove from place of plate curvature to anterior end; nodes on each side of median groove opposite sides of nodose carinal ridge which occupies median groove from slightly in front of plate curvature to bar. Median groove shallow, and narrow in front of carinal ridge. Right oral margin with node at apex of side curvature. Anterior end sharp. Length of right side slightly greater than that of left.

The sharp anterior end distinguishes this species from *S. corrugatus*.

Cherryvale shale (Fontana), Loc. 4a. Gunnell coll. no. 65.

STREPTOGNATHODUS SUBDIVISUS
Gunnell, n. sp.
Plate 32, figure 16

Oral surface of plate bearing row of transverse ridges on each side of shallow, narrow, median groove; ridges of about equal strength, and joining longitudinal ridge at oral margins; posterior area with nodes on right lobate portion, nodose longitudinal ridges on central part, and few nodes on left lobate portion. Carinal ridge occupying small posterior portion of median groove. Length of right side of plate slightly greater than that of left. Left side of plate with flange on basal portion. Anterior end sharp.

The presence of two lobes on the plate distinguishes this species from *S. ruidus*.

Cherryvale shale, Loc. 4c. Gunnell coll. no. 66.

STREPTOGNATHODUS RUIDUS
Gunnell, n. sp.
Plate 32, figure 17

Plate oral surface with row of transverse ridges on each side of anterior half of broad, shallow, median groove; nodes on anterior end, and row of rather large irregularly shaped nodes on each side of median groove opposite sides of carinal ridge. Transverse ridges with surfaces oval in cross-section in longitudinal and transverse directions. Right, lobate area small bearing single large node on oral surface. Carinal ridge extending throughout posterior part of median groove to more than half of plate length, and bearing nodes on anterior portion. Outline of oral surface scallop-like on both sides. Plate slightly curving toward right side.

The extension of the carinal ridge through over one-half the total length of the plate distinguishes this species from *S. subdivisus*.

Cherryvale shale, Loc. 4b. Gunnell coll. no. 67.

STREPTOGNATHODUS RUGOSUS
Gunnell, n. sp.
Plate 32, figure 18

Oral surface of plate bearing row of transverse ridges on each side of broad, deep, median groove anterior to anterior extremity of carinal ridge; posterior four-elevenths of median groove total length occupied by carinal ridge; posterior portion bearing nodose ridge on each side of median groove opposite sides of carinal ridge, left one of which bears node anteriorly, and posteriorly on side of plate. Left posterior side of plate slightly lobate. Right side of plate bearing flange on basal portion. Sides of plate equal in length. Plate curving toward left anterior side. Anterior end of plate moderately sharp.

The broad deep medium groove on the oral surface of the plate distinguishes this species from *S. subdivisus*.

Cherryvale shale, Loc. 4d. Gunnell coll. no. 68.

STREPTOGNATHODUS MINUTUS
Gunnell, n. sp.
Plate 32, figure 65

General shape sublanceolate. Plate oral surface bearing row of nodes on each side of median groove. Carinal ridge occupying median groove throughout posterior five-eighths of plate total length. Small lobe on left side of plate, bearing three nodes on oral surface. Length of right side of plate about three-fourths that of left. Anterior end sharp.

The small lobe distinguishes this species from *S. elegantulus* Stauffer and Plummer.

Chanute shale (Quivira), Loc. 3a. Gunnell coll. no. 69.

STREPTOGNATHODUS CHANUTENSIS
Gunnell, n. sp.
Plate 32, figures 66, 67, 68

Plate oral surface bearing row of transverse ridges on each side of median groove with smaller ridges occurring opposite sides of carinal ridge. Carinal ridge occupying median groove throughout posterior five-twelfths of plate total length. Right and left, elongate, lateral lobes

nodose on oral surfaces. Anterior end sharp. Length of right side of plate equal to that of left.

The two lateral lobes distinguish this species from *S. rugosus*, which has but one lateral lobe.

Chanute shale (Quivira), Loc. 3a. Gunnell coll. no. 70, 71.

STREPTOGNATHODUS CURVATUS
Gunnell, n. sp.
Plate 33, figure 1

Anterior half of plate curving toward left side. Plate oral surface with row of short transverse ridges or slightly elongate nodes on each side of median groove. Carinal ridge occupying median groove throughout posterior eight-thirteenths of plate total length. Median groove anterior to anterior extremity of carinal ridge with row of small nodes. Left, lobate portion of plate bearing few nodes on oral surface. Sides about equal in length. Anterior end blunt.

The row of nodes in the anterior portion of the median groove on the oral surface distinguishes this species from *S. rugosus*.

Chanute shale (Quivira), Loc. 6a. Gunnell coll. no. 72.

STREPTOGNATHODUS STRIGILLATUS
Gunnell, n. sp.
Plate 33, figure 2

Plate oral surface bearing seven transverse ridges on each side of small, median groove anterior to anterior extremity of nodose carinal ridge; areas opposite sides of carinal ridge bearing nodes and nodose ridges. Carinal ridge occupying median groove throughout posterior eight-fifteenths of plate total length. Flanges on basal portion of plate sides.

The small medium groove distinguishes this species from *S. clarki*.

Chanute shale (Quivira), Loc. 6a. Gunnell coll. no. 73.

STREPTOGNATHODUS CLARKI Gunnell, n. sp.
Plate 33, figure 3

Plate oral surface with length to width ratio of 15 to 7; bearing eight to ten transverse ridges on each side of small, shallow median groove; areas opposite sides of carinal ridge bearing nodes, and nodose ridges. Carinal ridge occupying median groove throughout posterior one-half of plate total length. Outline of right side irregular. Sides of plate bearing flanges on basal portions. Anterior end sharp.

The greater number of transverse ridges anterior to the carinal ridge distinguishes this species from *S. strigillatus*.

Chanute shale (Quivira), Loc. 6a. Gunnell coll. no. 74.

STREPTOGNATHODUS ELONGATUS
Gunnell, n. sp.
Plate 33, figure 30

Plate gently curving toward left side. Length to width ratio of plate oral surface 4 to 1. Median groove on oral surface increasing gradually in strength from anterior extremity to posterior end of plate on either side of which occur nodes or transverse ridges, and in which occur few small nodes in anterior half with nodose carinal ridge occurring in posterior one-third of groove total length. Oral surface of left, lobate portion of plate bearing few nodes. Sides of plate

bearing flanges on basal portion. Anterior end blunt.

The greater length to width ratio of the plate oral surface distinguishes this species from *S. curvatus*.

Americus limestone, Loc. 7. Gunnell coll. no. 75.

STREPTOGNATHODUS WALTERI Gunnell, n. sp.
Plate 33, figure 31

Length to width ratio of plate oral surface 27 to 11. Median groove on oral surface biconvex in outline anterior to anterior extremity of carinal ridge. Carinal ridge nodose; occupying posterior ten-twenty sevenths total length of median groove. About 21 short transverse ridges occur on left side, and 19 on right side of oral surface with nodes on right, lobate portion. Large flange on basal portion of left side of plate. Anterior end blunt.

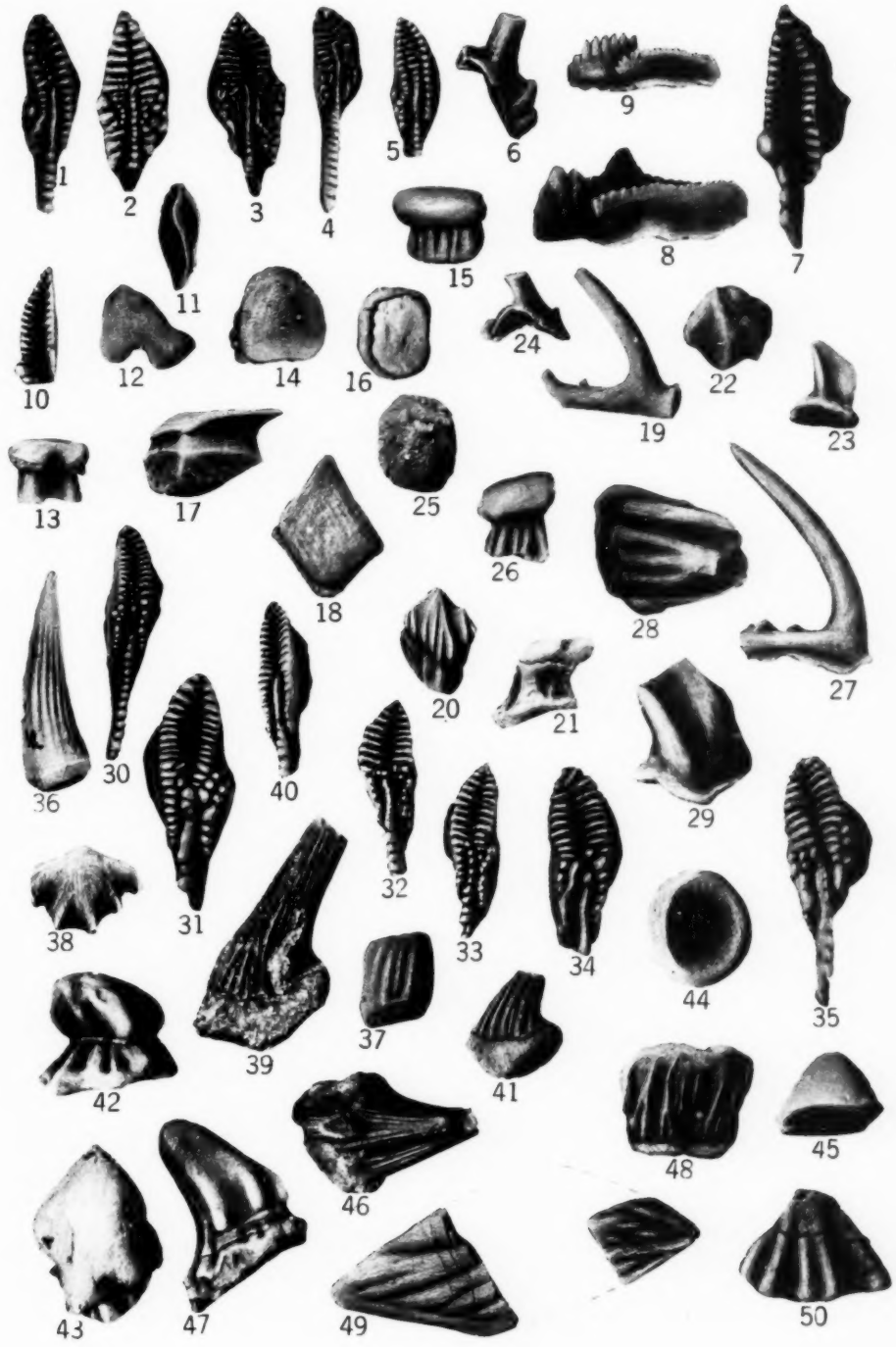
The greater length to width ratio of the plate oral surface distinguishes this species from *S. wabaunsensis*.

Americus limestone, Loc. 7. Gunnell coll. no. 76.

EXPLANATION OF PLATE 33

FIGS.

1—*Streptognathodus curvatus* Gunnell, n. sp., ×25. Oral view.
2—*Streptognathodus strigillatus* Gunnell, n. sp., ×25. Oral view.
3—*Streptognathodus clarki* Gunnell, n. sp., ×25. Oral view.
4—*Idiognathodus farrelli* Gunnell, n. sp., ×25. Oral view.
5—*Idiognathodus multinodosus* Gunnell, n. sp., ×25. Oral view.
6—*Euprioniodina* ? sp., ×25. Side view.
7, 8—*Cavusgnathus gigantus* Gunnell, n. sp., ×25. Oral and side views.
9—*Cavusgnathus lautus*, n. sp., ×25. Side view.
10, 11—*Cavusgnathus missouriensis* Gunnell, n. sp., ×25. Oral and aboral views.
12, 13—*Kirkella indentata* Gunnell, n. sp., ×25. Oral and anterior views.
14, 15, 16—*Kirkella typicalis* Gunnell, n. sp., ×25. Oral, side, and aboral views.
17, 18—*Holmesella speni* Gunnell, n. sp., ×25. Side and oral views.
19—*Subprioniodus* sp., ×25. Side view.
20, 21—*Cooperella striata* Gunnell, n. sp., ×25. Oral and side views.
22, 23—*Cooleyella simplex* Gunnell, n. sp., ×25. Oral and side views.
24—*Euprioniodina* ? sp., ×25. Side view.
25, 26—*Kirkella elleptica* Gunnell, n. sp., ×25. Oral and side views.
27—*Subprioniodus* sp., ×25. Side view.
28, 29—*Williamsella typicalis*, n. sp., ×25. Oral and antero-oral views.
30—*Streptognathodus elongatus* Gunnell, n. sp., ×25. Oral view.
31—*Streptognathodus walteri* Gunnell, n. sp., ×25. Oral view.
32—*Streptognathodus wabaunsensis* Gunnell, n. sp., ×25. Oral view.
33—*Streptognathodus acuminatus* Gunnell, n. sp., ×25. Oral view.
34—*Streptognathodus farmeri* Gunnell, n. sp., ×25. Oral view.
35—*Streptognathodus flangulatus* Gunnell, n. sp., ×25. Oral view.
36—*Paleoniscus* sp., ×25. Side view.
37—*Holmesella crassa* Gunnell, n. sp., ×25. Oral view.
38—*Cooleyella quinqueloba* Gunnell, n. sp., ×25. Oral view.
39, 41—*Idiacanthus* sp., ×25. Side views.
40—*Streptognathodus simplex* Gunnell, n. sp., ×25. Oral view.
42, 43—*Hammondella globosa* Gunnell, n. sp., ×25. Side and oral views.
44, 45—*Paleoniscus* sp., ×25. Aboral and side views.
46—*Idiacanthus trispinosus* Gunnell, n. sp., ×25. Oral view.
47—*Hammondella crassa* Gunnell, n. sp., ×25. Side view.
48—*Williamsella striata* Gunnell, n. sp., ×25. Oral view.
49, 50—Fish scales, ×25. Oral views.



Gunnell, Pennsylvanian conodonts

STREPTOGNATHODUS WABAUNSENSIS
Gunnell, n. sp.
Plate 33, figure 32

Oral surface with nine transverse ridges anterior to anterior extremity of carinal ridge; posterior eight being cut by small median groove. Greatest width of oral surface anterior to mid-length of plate. Oral surface to right of carinal ridge bearing nodes; left postero-lateral area bearing nodose, longitudinal ridge. Anterior end sharp.

The greater length to width ratio of *S. acuminatus* distinguishes it from this form.

Americus limestone, Loc. 7. Gunnell coll. no. 77.

STREPTOGNATHODUS ACUMINATUS
Gunnell, n. sp.
Plate 33, figure 33

Length to width ratio of plate 23 to 7. Median groove on oral surface slightly biconvex in outline anterior to anterior extremity of nodose carinal ridge. Ten transverse ridges occur on each side of biconvex portion of median groove. Carinal ridge nodose, to right of which occur nodes, and to left of which occur single row of nodes. Left side of plate with flange on basal portion. Anterior end sharp.

The sharp anterior end distinguishes this species from *S. walteri.*

Americus limestone, Loc. 7. Gunnell coll. no. 78.

STREPTOGNATHODUS FARMERI
Gunnell, n. sp.
Plate 33, figure 34

Length to width ratio of plate 13 to 5. Median groove on oral surface biconvex in outline anterior to anterior extremity of carinal ridge. Carinal ridge occupying posterior one-third of total length of median groove. About nine transverse ridges on oral surface of plate each side of biconvex portion of median groove. To right of carinal ridge occur single row of nodes and ridge; nodes on left poster-lateral area of oral surface. Flange largest on right basal side of plate.

The biconvex outline of the medium groove on the oral surface distinguishes this species from *S. flangulatus.*

Americus limestone, Loc. 7. Gunnell coll. no. 79.

STREPTOGNATHODUS FLANGULATUS
Gunnell, n. sp.
Plate 33, figure 35

Oral surface of plate with row of ten transverse ridges on right side, and eight transverse ridges on left side of narrow, deep, median groove anterior to anterior extremity of nodose carinal ridge; opposite each side of carinal ridge occurs longitudinal ridge posterior to small nodose areas. Right postero-lateral side of plate bearing large basal flange; upper margin with three nodes. Outline of oral surface serrate.

The larger basal flange on the right side of the plate distinguishes this species from *S. farmeri.*

Americus limestone, Loc. 7. Gunnell coll. no. 80.

STREPTOGNATHODUS SIMPLEX Gunnell, n. sp.
Plate 33, figure 40

Oral surface V-shape in cross-section. Sides of longitudinal groove

on oral surface anterior to carinal ridge bearing transverse ridges. Oral margins opposite sides of carinal ridge bearing nodes of which front nodes on left side almost form ridges. Carinal ridge on posterior five-elevenths of plate total length. Sides of plate vertical with flanges on basal portion.

The absence of nodes in the median groove of the oral surface distinguishes this species from *S. elongatus*.

Americus limestone, Loc. 7. Gunnell coll. no. 81.

Genus CAVUSGNATHUS Harris and Hollingsworth, 1933

Plate sublanceolate and connected postero-laterally to short denticle-bearing bar. Plate oral surface bearing submedian, longitudinal groove. Denticles or short transverse ridges marking each oral margin. One oral margin terminating at posterior end of plate, other oral margin continuous with bar. Aboral surface concave, with longitudinal groove separating two subequal areas.

CAVUSGNATHUS LAUTUS Gunnell, n. sp.
Plate 31, figure 67, 68

Plate sublanceolate. Oral surface of plate bearing row of transverse ridges on each side of median furrow. Bar high and bearing six denticles of rather uniform size. Flanges on basal portion of plate sides. Anterior end sharp.

The uniform size of the denticles on the bar distinguishes this species from *C. missouriensis*, whose largest denticle occurs at the union of the bar and the plate as in *C. gigantus*.

Cherryvale shale (Fontana), Loc. 4a. Gunnell coll. no. 82.

CAVUSGNATHUS GIGANTUS Gunnell, n. sp.
Plate 33, figure 7, 8

Plate sublanceolate. Length to width ratio of oral surface of plate 3 to 1. Median groove broad and deep; sides with transverse ridges except left posterior side which bears large thin denticle, anterior to which occur small nodes and posterior to which occur smaller denticles on bar. Right side of plate bearing broad, rather flat flange on basal portion. Anterior end sharp. The posterior part of the bar is broken from the figured specimen.

The broad basal flange distinguishes this species from *C. missouriensis*.

Chanute shale, Loc. 6b. Gunnell coll. no. 83.

CAVUSGNATHUS LAUTUS, n. sp.
Plate 33, figure 9

This specimen is larger and bears more denticles on the bar than the one from the Cherryvale. However, they are both of the same species.

Chanute shale (Quivira), Loc. 6a.

CAVUSGNATHUS MISSOURIENSIS Gunnell, n. sp.
Plate 33, figures 10, 11

Plate sublanceolate. Median groove V-shape in cross-section; sides with transverse ridges except left posterior side which bears denticle, posterior to which occurs smaller denticles on bar. Sides of plate high, bearing small flange on each basal antero-lateral side. Anterior end sharp. The posterior portion of the bar is broken from the figured specimens.

The absence of a broad basal flange distinguishes this species from *C. gigantus*.

Chanute shale Loc. 6b. Gunnell coll. no. 84.

Genus GONDOLELLA Stauffer and Plummer, 1932

General shape lingulate to lanceolate; bilaterally subsymmetrical. Aboral surface bearing furrowed keel. Posterior part of keel bearing collar. Oral surface bearing median row of denticles and nodes or sinuous ridges.

The writer in orienting the species of this genus has had in mind the relationship that seems to exist between the genus and modern cyclostomes (Petromyzon). If the specimens that are referred to this genus can be compared to the central rasping teeth of Petromyzon it will be seen that the denticles are inclined toward the posterior end of the animal.

The system of orientation adopted by the writer was not followed by the authors of the genus.

GONDOLELLA MERRILLI Gunnell, n. sp. Plate 32, figures 48, 49, 50

General shape sublanceolate. Length to width ratio 32 to 9. Oral surface with sinuous ridges on each side of median row of 13 denticles. Denticles decreasing in size from second anterior denticle to large, obliquely projecting, posterior denticle. Keel on aboral surface gradually decreasing in width from collar to anterior extremity.

The greater length to width ratio distinguishes this species from *G. lingulata*, and *G. sublanceolata*.

Chanute shale (Quivira), Loc. 3a. Gunnell coll. no. 85, 86.

GONDOLELLA LINGULATA Gunnell, n. sp. Plate 32, figures 51, 52

General shape lingulate. Length to width ratio 25 to 9. Oral surface with irregular, transverse ridges on each side of median row of 12 denticles. Denticles of median row subelliptical in cross-section, and of equal size. Keel on aboral surface slightly decreasing in size from collar to anterior extremity. Anterior end blunt.

The uniform size of the median row of denticles distinguishes this species from *G. merrilli*.

Chanute shale (Quivira), Loc. 3a. Gunnell coll. no. 87.

GONDOLELLA SUBLANCEOLATA Gunnell, n. sp. Plate 32, figures 53, 54, 55

General shape sublanceolate. Length to width ratio 27 to 5. Oral surface with broad transverse nodes on each side of median row of 12 spatulate denticles. Denticles decreasing in size from third denticle to anterior end, to large, obliquely projecting, posterior denticle. Collar on aboral surface with subtriangular outline.

Large posteriorly directed denticles distinguish this species from *G. merrili*.

Chanute shale (Quivira), Loc. 6a. Gunnell coll. no. 88.

GONDOLELLA SINUATA Gunnell, n. sp. Plate 32, figures 56, 57, 58

General shape sublanceolate. Length to width ratio 28 to 9. Oral surface with reticulate area on each side of median row of 13 denticles. Denticles about equal in size. Keel on aboral

surface gradually decreasing in size from collar to anterior extremity. Posterior margin of collar extending posteriorly beyond posterior extremity of oral surface outline.

The smaller length to width ratio distinguishes this form from *G. merrili.*

Chanute shale (Quivira), Loc. 3a. Gunnell coll. no. 89, 90.

Class PLAGIOSTOMI

Order ACANTHODEI

Family ACANTHOESSIDAE Hay

As the structure of the forms referred to the genus *Holmesella* resembles the structure of the Acanthoessidae the writer proposes to discard the term Holmesellidae, Stauffer and Plummer.

Genus HOLMESELLA Gunnell, 1931

HOLMESELLA EQUILATERATA Gunnell, n. sp.
Plate 31, figures 38, 39

Plate sides almost vertical, outline as parallelogram, with two opposite angles of about 95 degrees each, and other two angles of about 35 degrees each; corners slightly rounded; length of sides equal. Base high and extending anteriorly with equal antero-lateral lobes. The oral surface is flat with rounded margins, probably resulting from wear.

Winterset limestone, Loc. 2b.

HOLMESELLA PARALLELATA Gunnell, n. sp.
Plate 31, figure 41

Outline resembling parallelogram with two opposite angles of about 110 degrees each, other two angles of about 70 degrees each. Length slightly greater than width. Base extending laterally beyond base of plate uniformly throughout length of one side. The oral surface is flat probably as a result of wear.

The lateral extension of the base beyond one side of the plate distinguishes this species from *H. parallella*, whose base extends beyond two sides of the plate.

Winterset limestone, Loc. 2b. Gunnell coll. no. 91.

HOLMESELLA ORNATA Gunnell, n. sp.
Plate 31, figure 42

Outline of plate subquadrangular with posterior sides slightly longer than anterior sides; forming sharp corner posteriorly; anterior, and lateral corners rounded. Plate high; sides incurving; oral surface bearing longitudinal ridges which originate on antero-lateral oral margins, and extend posteriorly. Base high, and anteriorly extended; bearing subequal antero-lateral lobes.

The ornate oral surface and subquadrangular outline of the plate distinguishes this species from *H. equilaterata.*

Winterset limestone, Loc. 5b. Gunnell coll. no. 92.

HOLMESELLA PARALLELLA Gunnell, n. sp.
Plate 31, figure 54

Outline trapezoidal. Length slightly greater than width. Outline of block-like plate almost congruent to outline of base, with one end of base extending beyond corresponding end of plate.

The trapezoidal outline distinguishes this species from *H. equilaterata.*

Winterset limestone, Loc. 2d. Gunnell coll. no. 93.

HOLMESELLA ELONGATA Gunnell, n. sp.
Plate 31, figures 55, 56

Outline trapezoidal. Length to width ratio of plate 2 to 1. Outline of block-like plate extending beyond outline of base except smallest end of base which extends beyond corresponding end of plate.

The greater length to width ratio of this species distinguishes it from *H. parallella*.

Winterset limestone, Loc. 2d. Gunnell coll. no. 94.

HOLMESELLA EQUILATERATA n. sp.
Plate 31, figures 57, 58

Specimens represented by figures 57 and 58, plate 31, are the same species as is represented by figures 38 and 39, plate 31.

The specimen figured on figures 57 and 58 shows a lamellar structure which becomes exposed in specimens of this genus after the exterior portion of the oral surface is removed. As a majority of the specimens collected show some degree of wear on the oral surface it appears that they were part of a grinding dentition.

Winterset limestone, Loc. 2d.

HOLMESELLA RHOMBOIDELIS Gunnell, n. sp.
Plate 31, figure 71

Base high, and slightly projecting anteriorly beyond outline of plate. Plate outline rhomboidal; anterior sides of equal length, but shorter than posterior sides also of equal length.

The greater length of the posterior sides of the plate distinguishes this species from *H. equilaterata*.

Iola limestone (Argentine), Loc. 3b. Gunnell coll. no. 96.

HOLMESELLA SPENI Gunnell, n. sp.
Plate 33, figures 17, 18

Plate outline as parallelogram with one small angle of about 70 degrees; posterior end opposite other small angle. Outline of base almost congruent with that of plate except for small antero-lateral extensions of former, and small postero-lateral extensions of latter. Re-entrant on all sides between lateral extremities of plate and base.

The re-entrant on all sides of the specimen between the lateral extremities of the plate and the base distinguishes this species from *H. rhomboidelis* whose sides are vertical.

Chanute shale (Quivira), Loc. 6a. Gunnell coll. no. 97.

HOLMESELLA CRASSA Gunnell, n. sp.
Plate 33, figure 37

Outline resembling parallelogram. Oral surface sloping uniformly on all sides from flat median portion toward lateral extremities, which occur at union of plate and base. The place of union of the base and the plate is indistinguishable, because of the shape of the specimen.

The uniformly sloping sides distinguishes this species from *H. parallelata*.

Americus limestone, Loc. 7. Gunnell coll. no. 98.

Class PLAGIOSTOMI

Order SELACHII

Genus COOLEYELLA Gunnell, n. gen.

General shape aviculiform. Base supporting bilaterally subsymmetrical plate. Base expanding toward aboral margins; sides smooth; aboral surface flat to concave. Plate subquandrangular to subelliptical in outline. Margins of plate extending laterally beyond upper surface of base with greatest extension on posterior margin. Oral surface smooth with lobate anterior margin. Plate with posterior edges sharp, and anterior edges rounded. Genotype, *C. peculiaris*, n. sp.

This genus is named in honor of Miss Maude Cooley.

COOLEYELLA SPATULATA Gunnell, n. sp.
Plate 31, figure 64

General shape of plate spatulate; oral surface smooth; anterior edge with three subequal lobes. Posterolateral edges of plate sharp.

The greater width to length ratio of *C. peculiaris* distinguishes it from this form.

Cherryvale shale (Fontana), Loc. 4a. Gunnell coll. no. 99.

COOLEYELLA PECULIARIS Gunnell, n. sp.
Plate 31, figures 65, 66

General shape aviculiform. Outline of base subelliptical, transverse diameter largest; posterior edge of base with notch. Width of plate greater than length. Edges of plate oral surface with large central lobe on anterior edge. Postero-basal side of plate with one node. On the figured specimen the oral and anterior surfaces of the plate are worn.

The greater width to length ratio of this species distinguishes it from *C. spatulata*.

Winterset limestone, Loc. 2d. Gunnell coll. no. 100.

COOLEYELLA QUINQUELOBA Gunnell, n. sp.
Plate 33, figure 38

Length to width ratio 14 to 19. Posterolateral sides forming 127 degree angle at posterior extremity. Anterior side bearing five lobes which form scallop-like outline. Oral surface smooth.

The five lobes on the anterior side distinguishes this species from *C. quadrilobata*.

Americus limestone, Loc. 7. Gunnell coll. no. 104.

COOLEYELLA QUADRILOBATA Gunnell, n. sp.
Plate 32, figure 23

Plate outline subcrescent shape with ends posteriorly directed. Anterior side forming four scallop-like lobes almost equidistant apart. Oral surface of plate smooth. Length to width ratio of plate as 3 to 2.

Four scallop-like lobes on the anterior side of the plate distinguishes this species from *C. cuspidata*.

Cherryvale shale, Loc. 4e. Gunnell coll. no. 102.

COOLEYELLA SIMPLEX Gunnell, n. sp.
Plate 33, figures 22, 23

Base subcircular in outline; vertical grooves on anterior portion; height small; upper part greatly constricted. Oral surface of plate with elongate, median lobe extending from summit to top of base. Broad shallow groove occurs opposite each side of

median lobe. Anterior margin of plate bearing three lobes. The postero-lateral portion of the plate is broken from the figured specimen.

The elongate median lobe on the oral surface distinguishes this species from *C. spatulata*, whose median lobe is restricted to the anterior margin.

Americus limestone, Loc. 7. Gunnell coll. no. 103.

COOLEYELLA CUSPIDATA Gunnell, n. sp.
Plate 32, figure 22

Outline of plate resembling outline of broad-ax. Anterior sides rather long, forming almost right angle at anterior end. Posterior side of plate with large median angle at posterior end. Posterior side of plate with large, median lobe bearing two grooves, and three ridges. Width to length ratio of plate 1 to 1. Oral surface smooth.

The three closely associated ridges on the anterior end of the plate distinguishes this form from *C. quadrilobata*.

Cherryvale shale, Loc. 4e. Gunnell coll. no. 101.

Genus COOPERELLA Gunnell, n. gen.

General shape aviculiform. Base supporting bilaterally subsymmetrical plate. Base constricted above flat to concave aboral surface. Outline of base subcircular to subelliptical. Plate margins extending laterally beyond upper surface of base with greatest extension in posterior dirction. Oral surface with longitudinal ridges. Genotype, *C. typicalis*, n. sp.

The markings may be worn from the oral surface of some specimens.

This genus is named in honor of Mr. C. L. Cooper.

COOPERELLA STRIATULA Gunnell, n. sp.
Plate 31, figure 69

Basal outline subcircular. Base greatly constricted immediately below plate; sides columnar. Outline of base smaller than that of plate. Plate width greater than length. Oral surface bearing about seven longitudinal subparallel ridges originating on antero-basal side of plate, and extending to postero-oral margins; median ridge largest, and other ridges slightly inclined toward anterior end of median ridge.

The extension of the seven longitudinal ridges along the oral surface to the postero-oral margins distinguishes this species from *C. selluliformis*, whose eight ridges terminate on the oral surface.

Cherryvale shale (Fontana), Loc. 4a. Gunnell coll. no. 105.

COOPERELLA SELLULIFORMIS Gunnell, n. sp.
Plate 31, figure 70

Basal outline subelliptical. Smallest diameter at mid-height of base. Distinct groove between base and plate. Plate with about eight vertical ridges which extend short distance along oral surface toward posterior end of plate. Width of plate greater than length. Width of base equal to width of plate.

The short length of the ridges on the oral surface distinguishes this species from *C. striatula*.

Cherryvale shale (Fontana), Loc. 4a. Gunnell coll. no. 106.

COOPERELLA SUBSULCATA Gunnell, n. sp.
Plate 31, figure 72

Base with subcircular outline; sides columnar; greatest constriction slightly above mid-height. Width, and length of plate equal. Plate outline subquadrangular. Oral surface bearing about eight longitudinal ridges beginning on antero-basal margin of plate, and extending to postero-oral margins; two large longitudinal grooves dividing oral surface into three areas with three largest ridges occupying median area.

Two large longitudinal grooves on the oral surface distinguishes this species from *C. striatula*.

Cherryvale shale (Fontana), Loc. 4a. Gunnell coll. no. 107.

COOPERELLA ERODA Gunnell, n. sp.
Plate 31, figures 73, 74, 75

Basal outline subcircular. Base with smooth sides; greatest constriction slightly above mid-height. Length of plate slightly greater than width. Oral surface with about six longitudinal ridges originating on antero-basal margin of plate, and extending toward posterior margin. As there are worn ridges on the oral surface of the figured specimens it appears that these forms represent a type of dentition.

The short ridges on the postero-basal aboral side of the plate distinguishes *C. rectistriata* from this species.

Cherryvale shale (Fontana), Loc. 4a. Gunnell coll. nos. 108, 109.

COOPERELLA RECTISTRIATA Gunnell, n. sp.
Plate 31, figures 76, 77

Basal outline subelliptical. Base sides smooth; greatest constriction slightly above mid-height. Width of base equal to width of plate. Plate outline subtriangular; width greater than length. Oral surface bearing about seven parallel ridges which begin at top of base on anterior side of plate, and extend to postero-oral margins. Postero-basal aboral sides of plate bearing few short ridges.

The greater width to length ratio of the plate distinguishes this species from *C. eroda*.

Cherryvale shale (Fontana), Loc. 4a. Gunnell coll. no. 110.

COOPERELLA sp.
Plate 32, figure 20

Cherryvale shale, Loc. 4e.

COOPERELLA ? sp.
Plate 32, figure 26

This specimen is distinctly different from the other specimens of *Cooperella*. It is referred to this genus because it is possible that it represents an immature *Cooperella*. It somewhat resembles some specimens of *Holmsella*. It may represent a gradational form between *Holmsella* and *Cooperella*.

Cherryvale shale, Loc. 4e.

COOPERELLA TYPICALIS Gunnell, n. sp.
Plate 32, figure 27

Basal outline subelliptical. Six subparallel ridges originating at antero-basal margin and continuous on oral surface, decreasing in size from point of origin to place of termination. Posterior part of oral surface smooth. Posterior extremity most highly elevated portion of tooth.

The greater length of the plate distinguishes this species from *C. subsulcata*.

Cherryvale shale, Loc. 4a. Gunnell coll. no. 111.

COOPERELLA STRIATA Gunnell, n. sp.
Plate 33, figures 20, 21

Base outline subelliptical; sides bearing concavities; greatest constriction slightly below top of base. Width of plate equal to length. Outline of plate subquadrangular. Oral surface bearing about eight ridges which originate on antero-basal margin of plate, and extend along oral surface; to right of longest ridge on oral surface occurs single large groove.

The greater number of ridges on the plate distinguishes this species from *C. typicalis*.

Americus limestone, Loc. 7. Gunnell coll. no. 112.

Genus FORTSCOTTELLA Gunnell, 1931

FORTSCOTTELLA GEMMICULA Gunnell, n. sp.
Plate 32, figure 35

Basal outline subcircular. Each side bearing four angular, parallel ridges each of which unite at upper extremity with corresponding ridge of opposite side. Posterior ridges longest; uniting at summit. Ridges successively longer from anterior to posterior.

The longer obliquely pointing ridges on the sides of the specimen distinguish this species from *F. semiserrata* Gunnell, 1931.

Chanute shale (Quivira), Loc. 3a. Gunnell coll. no. 112.

Genus HAMMONDELLA Gunnell, n. gen.

General shape aviculiform. Base supporting bilaterally subsymmetrical plate. Base with subcircular to subelliptical outline, irregular aboral surface, and smooth to columnar-like sides. Genotype *H. globosa*, n. sp.

This genus is named in honor of Mr. W. W. Hammond.

HAMMONDELLA GLOBOSA Gunnell, n. sp.
Plate 33, figures 42, 43

General shape aviculiform. Length to width ratio 18 to 11. Base subelliptical in outline; sides bearing grooves; tapering from basal margins to base of plate. Plate subpentagonal in outline. Lower portion of plate sides lobate. Oral surface smooth and convex.

The greater height to length ratio of the plate of *H. crassa* distinguishes it from this species.

Americus limestone, Loc. 7. Gunnell coll. no. 113, 114.

HAMMONDELLA CRASSA Gunnell, n. sp.
Plate 33, figure 47

Height to length ratio of plate 10 to 8. Plate bearing lobes on basal part of sides; summit blunt. Base broad; sides bearing imbricate structure.

The greater height to length ratio distinguishes this species from *H. globosa*.

Americus limestone, Loc. 7. Gunnell coll. no. 115.

Genus IDIACANTHUS Gunnell, n. gen.

Base large, rounded, and porous with one or more striated spines projecting from one plane. Genotype. *I. bellistriatus* n. sp.

IDIACANTHUS BELLISTRIATUS Gunnell, n. sp.
Plate 31, figure 60

Base, aboral surface flat; sides rounding. Shaft subelliptical in cross-

section, gently arching, and gradually tapering from base to summit. Sides of shaft bearing striations and parallel ridges; both groups decreasing in size upward, and converging along anterior edge.

As the sides of the shaft on *I. cameratus* bear only striations, the occurrence of ridges and striations on this species distinguishes it from the former.

Winterset limestone, Loc. 2d. Gunnell coll. no. 116.

IDIACANTHUS CAMERATUS Gunnell, n. sp.
Plate 32, figure 29

Base subcircular in outline; sides rounded; basal surface concave. Length to height ratio of base 3 to 2. Base of shaft covering base upper surface. Shaft gently arching in one direction; sides with striations originating at base of shaft, and coalescing on sides below summit. Summit sharp.

The absence of ridges on the shaft of this form distinguishes it from *I. bellistriatus*.

Cherryvale, shale, Loc. 4e. Gunnell coll. no. 117.

IDIACANTHUS sp.
Plate 33, figures 39, 41

Americus limestone, Loc. 7.

IDIACANTHUS TRISPINOSUS Gunnell, n. sp.
Plate 33, figure 46

Base irregular in shape surmounted by three obliquely projecting, striate spines. Largest spine on posterior portion of base upper surface, anterior to which occurs median sized spine; smallest spine occurring on anterior end of base.

The three projecting striate spines surmounted on the base distinguishes this species from *I. cameratus*. The latter species has a single spine on the base.

Americus limestone, Loc. 7. Gunnell coll. no. 118.

Genus KIRKELLA Gunnell, n. gen.

General shape selluliform. Base supporting large bilaterally subsymmetrical plate. Base with subcircular to subelliptical outline, uneven aboral surface, and columnar-like sides. Plate subquadrangular in outline, edges oval in cross-section, and exterior without ornamentation. Lateral margins of plate extending beyond upper margins of base. Genotype, *K. typicalis*, n. sp.

This genus is named in honor of Mr. Edwin Kirk.

KIRKELLA TYPICALIS Gunnell, n. sp.
Plate 33, figures 14, 15, 16

Plate semi-subelliptical in outline; edges oval in cross-section. Sides of base bearing vertical grooves. Greatest diameter of base at union with plate; about three-fourths as great as that at mid-height of plate.

The indentation on the plate of *K. indentata* distinguishes it from this species.

Chanute shale, (Lane), Loc. 6b. Figure 14 represents the Holotype, and figures 15 and 16 represent paratypes. Gunnell coll. nos. 120–23.

KIRKELLA INDENTATA Gunnell, n. sp.
Plate 33, figures 12, 13

Plate outline semi-subelliptical with indentation on side opposite elliptical portion. Height of plate about

two-thirds that of base. Diameter of base at union with plate about nine-thirteenths as great as diameter at mid-height of plate.

The indentation on the plate distinguishes this species from *K. typicalis*.

Chanute shale (Lane), Loc. 6b. Gunnell coll. no. 119.

KIRKELLA ELLIPTICA Gunnell, n. sp.
Plate 33, figures 25, 26

Plate outline subelliptical. Height of plate about seven-eighths that of base. Sides of base bearing vertical grooves which decrease in size from basal margin upward. Greatest diameter of base at union with plate being about five-eighths that of plate at mid-height.

The subelliptical outline of the plate distinguishes this species from *K. typicalis*.

Americus limestone, Loc. 7. Gunnell col. no. 124.

Genus MOREYELLA Gunnell, n. gen.

General shape aviculiform. Base supporting bilaterally symmetrical plate. Base with subcircular outline, irregular aboral surface, and smooth or columnar sides expanding toward aboral margin. Plate large; outline subhexagonal, with margins extending laterally beyond upper surface of base. Oral surface with two longitudinal depressions separating oral surface into three subparallel elongate lobes. Genotype, *M. typicalis*, n. sp.

This genus is named in honor of Mr. Phil Morey who has assisted the writer in these investigations.

MOREYELLA TYPICALIS Gunnell, n. sp.
Plate 31, figure 53

Length to width ratio of plate 11 to 6. Median lobe large and oval in cross-section; anterior end rounded; greatest diameter about one-fourth the total length of plate; gradually tapering to point posteriorly. Areas between lobes oval in cross-section. Lateral lobes small, subangular in cross-section, and traversed by shallow longitudinal groove.

The greater length to width ratio of the plate distinguishes this species from *M. aviculiformis*.

Winterset limestone, Loc. 5c. Gunnell coll. no. 125.

MOREYELLA AVICULIFORMIS Gunnell, n. sp.
Plate 31, figure 63

Length to width ratio of plate 19 to 16. Median lobe oval in cross-section, moderately large; outline of anterior end semicircular; greatest diameter about one-fourth total length of plate; tapering to point posteriorly. Areas between lobes oval in cross-section. Lateral lobes traversed by longitudinal grooves forming scallop-like cross-section. Antero-oral surface of median lobe with longitudinal groove.

The grooves on the lobes of *M. trilobata* distinguish it from this species.

Cherryvale shale (Fontana), Loc. 4a. Gunnell coll. no. 126.

MOREYELLA TRILOBATA Gunnell, n. sp.
Plate 32, figure 24

Length to width ratio of plate 3 to 2. Lateral lobes slightly more than one-third total length of plate. Each lobe bearing median groove through-

out total length. Sides of lobes rather steep. Depressions between lobes subangular in cross-section at lowest part.

The median grooves in the lobes of the plate distinguish this species from *M. aviculiformis*.

Cherryvale shale, Loc. 4e. Gunnell coll. no. 127.

Genus PETRODUS McCOY

PETRODUS ? sp.

Plate 32, figure 28

This specimen is probably a small scale related to *Petrodus buttersi*.

Cherryvale shale, Loc. 4e.

Genus WILLIAMSELLA Gunnell, n. gen.

General shape cuneiform. Base supporting thick bilaterally subsymmetrical plate. Base extending laterally beyond basal margins of plate. Aboral surface concave. Plate sides bearing grooves and striations. Genotype, *W. typicalis* n. sp.

This genus is named in honor of Dr. J. S. Williams.

WILLIAMSELLA TYPICALIS Gunnell, n. sp.

Plate 32, figure 21

Base subelliptical in outline. Plate broad, high, and gently curving posteriorly in one plane. Anterior side of plate with large, shallow grooves extending from upper surface of base to summit of tooth.

The large shallow grooves on the anterior side of the plate distinguish this species from *W. striata*, which has numerous small grooves on the anterior side of the plate.

Cherryvale shale, Loc. 4e Gunnell coll. no. 128.

WILLIAMSELLA ? sp.

Plate 32, figure 25

This specimen is probably the plate of a species of *Williamsella*.

Cherryvale shale, Loc. 4e.

WILLIAMSELLA TYPICALIS, n. sp.

Plate 33, figures 28, 29

This specimen is larger than the specimens from the Cherryvale; otherwise they are apparently the same species.

Americus limestone, Loc. 7.

WILLIAMSELLA STRIATA Gunnell, n. sp.

Plate 33, figure 48

Plate summit smooth; anterior and posterior sides with ridges originating at lower margins of plate and decreasing in size toward summit. Base subquadrangular in outline; sides oval in cross-section.

The numerous small grooves on the anterior side of the plate distinguish this species from *W. typicalis*.

Americus limestone, Loc. 7. Gunnell coll. no. 129.

Class OSTEICHTHYES

Superorder GANOIDEI

Genus PALEONISCUS Agassiz

Single, elongate tooth, straight to slightly arching; outline of cross-section subcircular; sides smooth, frosted or bearing many longitudinal grooves. Aboral surface concave.

In addition to the species herein described this genus includes the following: *Acodus? circulatus* Gunnell, 1931, and *Acodus? simplex* Gunnell, 1931.

PALEONISCUS sp.
Plate 31, figure 22

Cone shape with greatest diameter at base. Outline subcircular. Basal margins angular in cross-section. Height to width ratio 15 to 11. In some specimens the cone is associated with a base.

Galesburg shale, Loc. 2a.

PALEONISCUS sp.
Plate 32, figure 15

Height to width ratio 3 to 1. Tooth straight, and gradually tapering from base to summit; sides smooth. The basal part of this tooth is broken.

Cherryvale shale, Loc. 4e.

PALEONISCUS sp.
Plate 32, figure 31

Chanute shale (Quivira), Loc. 3a.

PALEONISCUS sp.
Plate 33, figure 36

Tooth gently arching and gradually increasing in size from summit to base. Circular ridge on margin of basal surface surrounding central concavity. Sides with longitudinal grooves originating slightly above basal margin and discontinuing slightly below summit.

Americus limestone, Loc. 7.

PALEONISCUS sp.
Plate 33, figures 44, 45

These specimens are the translucent tips of fish teeth, the base of which is absent.

Americus limestone, Loc. 7.

FISH SCALE
Plate 31, figure 62

Winterset limestone, Loc. 2b.

FISH SCALES
Plate 33, figures 49, 50

Americus limestone, Loc. 7.

FISH TOOTH ?
Plate 32, figure 39

This specimen is probably an immature tooth. The specific description will be deferred until an attempt has been made to find larger specimens.

Chanute shale (Quivira), Loc. 3a.

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THE NAUTILOID CEPHALOPODS OF THE MIDWAY GROUP

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ABSTRACT

At least eight species of nautiloid cephalopods occur in the Midway (basal Eocene) of the Gulf Coastal Plain; these are referable to three genera: *Eutrephoceras*, *Cimomia*, and *Hercoglossa* [=*Enclimatoceras*]. Each of these genera is discussed at some length and the North American species that are referable to it are listed. All four of the previously described species of Midway nautiloids are discussed and four new ones are described and illustrated.

The Midway is a group of marine formations that outcrops in an almost continuous narrow belt extending entirely across the Gulf Coastal Plain from Coahuila and Nuevo Leon on the west to Illinois on the north and Georgia on the east. Its western portion has not been satisfactorily subdivided into formations,[1] but in Mississippi and Alabama three distinct subdivisions can be recognized; these are, from bottom to top, the Clayton formation, the Porters Creek [=Sucarnochee] clay, and the Naheola formation. The literature that treats of the Midway was summarized by Duessen[2] in 1914 and again in 1924. In 1925 Cook[3] correlated the various subdivisions of the Midway in Mississippi and Alabama; in 1926 Helen Jeanne Plummer[4] published an extensive monograph on the foraminifera of the Midway of Texas; and in 1931 Gardner[5] published a comparison of the Midway and related foreign faunas.

The age of the Midway has long been a favorite subject for discussion. The earliest geologists of the region referred part of what is now known as Midway to the Cretaceous and part to the Tertiary, but gradually its unity came to be recognized and all of it was referred to the Eocene; the work of Harris[6] in 1896 fixed the boundaries of the group. The Eocene

[1] The names Wills Point clays, Kemp clays, Elstone formation, and Squirrel Creek formation have been applied locally to subdivisions of the Texas Midway, but no general application of any of them has been made.

[2] Deussen, Alexander, Geology and underground waters of the southeastern part of the Texas Coastal Plain: *U. S. Geol. Survey, Water-Supply Paper* 335, pp. 30–31, 1914; Geology of the Coastal Plain of Texas west of Brazos River: *U. S. Geol. Survey, Prof. Paper* 126, p. 41, 1924.

[3] Cook, C. W., Correlation of the Eocene formations in Mississippi and Alabama: *U. S. Geol. Survey, Prof. Paper* 140, pp. 133–134, 1925.

[4] Plummer, Helen Jeanne, Foraminifera of the Midway formation in Texas: *Texas Univ., Bull.* 2644, 1926.

[5] Gardner, Julia, Relation of certain foreign faunas to Midway fauna of Texas: *Amer. Assoc. Petroleum Geologists, Bull.*, vol. 15, pp. 149–160, 1931.

[6] Harris, G. D., The Midway stage: *Bull. Amer. Paleontology*, vol. 1, no. 4, pp. 115–170, 1896.

age of the Midway was not thereafter seriously questioned until 1926 when Scott[7] stated that he believed the lower part of the Midway is correlative with the Danian of northwestern Europe. The exact age of the Danian is somewhat doubtful but it is generally regarded as uppermost Cretaceous. Scott's conclusion was accepted by Douvillé[8] but was emphatically rejected by Gardner.[9] Scott apparently correlated these two horizons largely on the basis of the nautiloid cephalopods, and he regarded *Enclimatoceras* [*Hercoglossa*] *ulrichi* White of the Midway as conspecific with *Nautilites* [*Hercoglossa*] *danicus* Schlotheim of the Danian. Gardner concluded that these two forms are not conspecific, and, calling attention to Ravn's statement[10] that the nautiloids are of little significance as far as determining the age of the Danian is concerned, she inferred that the Danian nautiloids are "of little value in exact correlation." We are convinced that she was right in the first of these conclusions but we are very skeptical of the latter for we believe that the nautiloid cephalopods, if carefully differentiated and not lumped together, can be used very effectively for intra- and intercontinental correlation. Theoretically they should be much better stratigraphic indices than most of the other fossils on which Tertiary correlations are usually based, for cephalopods are free and rapid swimmers and are not attached to the bottom or confined to the shallow waters, and in addition their empty shells drift widely after the death of the animals that secrete them.

It was this difference of opinion among the paleontologists in regard to the age of the Midway and the affinities of its nautiloid cephalopods that stimulated us to take up the present study, for the senior author has for some time been particularly interested in tetrabranchiate cephalopods and the junior author has been working on the Cretaceous-Eocene contact in Mississippi and Alabama. We decided to approach the problem from a purely biological viewpoint for it is obvious from the recent report of Trowbridge[11] that the significance of the unconformity that separates the Midway from the underlying Upper Cretaceous strata must be determined almost entirely on a paleontological basis. As might have been expected, most of the results achieved were of biological rather than stratigraphical significance, but a few conclusions with a stratigraphical bearing were reached

[7] Scott, Gayle, Études stratigraphiques et paléontologiques sur les terrains crétacés du Texas: Thesis, Université de Grenoble, pp. 114–118, 1926; On a new correlation of the Texas Cretaceous: *Amer. Jour. Sci.*, ser. 5, vol. 12, pp. 157–161, 1926.

[8] Douvillé, H., La Cardita Beaumonti en Amérique: *Compte Rendu sommaire des Séances Soc. géol. France* 1929, Fascicule 12, p. 167, 1929.

[9] Gardner, Julia, On Scott's new correlation of the Texas Midway: *Amer. Jour. Sci.*, ser. 5, vol. 12, pp. 452–455, 1926; Relation of certain foreign faunas to Midway fauna of Texas: *Amer. Assoc. Petroleum Geologists, Bull.*, vol. 15, p. 160, 1931.

[10] Ravn, J. P. J., Sur le placement géologique du Danien: *Mus. Min. et Géol., l'Univ. Copenhague communications géol.* no. 5, p. 32, 1925.

[11] Trowbridge, A. C., Tertiary and Quaternary geology of the Lower Rio Grande region, Texas: *U. S. Geol. Survey, Bull.* 837, p. 29, 1932.

and these can be briefly summarized.

In the first place it is our opinon that at least eight species of nautiloids, representing three genera, occur in the Midway and that none of these is conspecific with *Hercoglossa danica* of the Danian of northwestern Europe. Nevertheless, the rather striking similarity of *H. ulrichi* of the Midway and *H. danica* of the Danian seems to indicate that there probably was no great difference in the time of deposition of the sediments that contain these two forms. All of the specimens of *H. ulrichi* s. s. that we have seen came from the lower portion of the Midway, and these seem to indicate that the basal Midway of Texas and Arkansas is of approximately the same age as the basal Midway of Alabama. Also, the fact that two of the nautiloid genera, *Hercoglossa* and *Cimomia*, which are so abundant in the Midway are represented also in the Eocene of Maryland seems to indicate the possibility that part of the Pamunkey group is more closely related to the Midway than is generally believed.[12] The relationship between *Hercoglossa merriami* Dickerson of the Martinez formation (lower Eocene) of California and the Midway representatives of *Hercoglossa* is not clear to us due to the imperfection of the only representative of the California species that has so far been figured, but the occurrence of representatives of both *Hercoglossa* and *Eutrephoceras* in the Martinez as well as in the Midway seems to substantiate the conclusion of Weaver[13] and Dickerson[14] that the Martinez is the approximate time equivalent of the Midway.

The present report is based on a study of specimens collected by the junior author during the 1931 summer field-season and those already in the paleontological collections of the State University of Iowa. In addition, a large collection of Midway nautiloids was kindly loaned us by the Alabama Museum of Natural History, and Mr. F. E. Vestal of Mississippi State College generously presented us with another; acknowledgement is hereby tendered for this aid. Special acknowledgement is due also to the recent work of Dr. L. F. Spath on Tertiary nautiloids, which has led to a far better understanding of that group than was ever achieved in the past.

SYSTEMATIC DESCRIPTIONS

Genus EUTREPHOCERAS Hyatt

Unfortunately, there is considerable uncertainty as to what should be regarded as the genotype of *Eutrephoceras*. Hyatt[15] established the genus in 1894 and stated that the type is "*Eutrephoceras dekayi*," a

[12] Cooke and Stephenson (*Jour. Geology*, vol. 36, p. 147, 1928) state that "the consensus of opinion is that the lowest member of the Pamunkey group of Maryland is not older than the Wilcox group of the Gulf region"—the Wilcox overlies the Midway unconformably.

[13] Weaver, C. E., Contribution to the paleontology of the Martinez group: *California Univ. Publ., Dept. Geol. Bull.*, vol. 4, no. 5, p. 112, 1905.

[14] Dickerson, R. E., Fauna of the Martinez Eocene of California: *California Univ. Publ., Dept. Geol. Bull.*, vol. 8, no. 6, p. 118, 1914.

[15] Hyatt, Alpheus, Phylogeny of an ac-

species originally described from the Navesink marl (Cretaceous) of New Jersey. Nevertheless, as has been noted by Reeside,[16] it appears from Hyatt's description of the genus and the specific discussion which follows it that Hyatt in reality based the genus on specimens from some horizon in the Cretaceous of one of the Dakotas, which he erroneously referred to the New Jersey species. Furthermore, Hyatt's specific description indicates that he allowed the species so much latitude that we are inclined to believe that he was studying representatives of more than one species, and it is obvious to us from the specimens available for study that several species of this genus are represented in the Cretaceous of the Western Interior. Presumably the correct procedure[17] in this case would be to ask the International Commission on Zoological Nomenclature to establish one of the forms figured by Hyatt as the type of his genus, but unfortunately the figured specimens represent only the extreme adapical portion of the conch and therefore it probably would be impossible to recognize conspecific mature forms. We have, therefore, reached the conclusion that for the present at least it will be best to interpret Hyatt's designation of the genotype literally and to regard *Eutrephoceras dekayi* (Morton) s. s. as the genotype. The original description[18] of this species is very brief and generalized, and the accompanying illustration is not very satisfactory, but fortunately both Meek[19] and Whitfield[20] have restudied and refigured the type specimen, and Whitfield[21] has figured and described additional specimens from the Navesink marl of New Jersey, which yielded the type specimen.

Forms which externally at least present the same general characters as the type of this genus are widespread and occur in Europe, Asia, and Africa as well as in both North and South America, and the genus seems to range from the Jurassic up into the lower Oligocene. Of the North American species that are known to us at least the following should be referred to this genus: *Nautilus dekayi* Morton of the Monmouth (Cretaceous) of New Jersey and adjacent areas, and the forms from the "Middle Marls" (Late Cretaceous or early Eocene) of New Jersey that Whitfield[22] erroneously referred to this spe-

quired characteristic: *Amer. Phil. Soc., Proc.*, vol. 32, no. 143, p. 555, 1894.

[16] Reeside, J. B., jr., A new nautiloid cephalopod, *Eutrephoceras sloani*, from the Eocene of South Carolina: *U. S. Nat. Mus., Proc.*, vol. 65, art. 5, p. 2, 1924; The cephalopods of the Eagle sandstone and related formations in the Western Interior of the United States: *U. S. Geol. Survey, Prof. Paper* 151, pp. 6–7, 1927.

[17] See Opinion 65 of the International Commission on Zoological Nomenclature.

[18] Morton, S. G., Supplement to the "Synopsis of the organic remains of the ferruginous sand formation of the United States," . . . : *Amer. Jour. Sci. and Arts*, ser. 1, vol. 23, p. 291, pl. 8, fig. 4, 1833.

[19] Meek, F. B., A report on the invertebrate Cretaceous and Tertiary fossils of the Upper Missouri Country: *U. S. Geol. Survey of the Terr.* (Hayden), vol. 9, pp. 496–498, text fig. 67, 1876.

[20] Whitfield, R. P., Gastropoda and Cephalopoda of the Raritan clays and Greensand marls of New Jersey: *U. S. Geol. Survey, Mon.* 18, pp. 243–244, pl. 37, figs. 2, 3; pl. 28, fig. 1, 1892.

[21] *Op. cit.*, pls. 37, 38.

[22] *Op. cit.*, p. 374, pl. 38, figs. 3, 4.

cies, and those from the Cretaceous of the Western Interior that Meek[23] erroneously referred to it; *N. dekayi* var. *montanaensis* Meek [a distinct species] of the Montana group (Upper Cretaceous) of Montana and South Dakota; *N. bryani* Gabb of the Vincentown (lower Eocene) of New Jersey; *N. cookanus* Whitfield of the lower Eocene of New Jersey; *N. stephensoni* Dickerson of the Martinez (lower Eocene) of California; *Eutrephoceras sloani* Reeside of the Black Mingo (lower Eocene) of South Carolina; *E. carolinense* Kellum of the Castle Hayne marl (upper Eocene) of North Carolina; *E. alcesense* Reeside of the Eagle sandstone (Upper Cretaceous) of Montana and Wyoming; *E. thomi* Reeside of the Eagle sandstone of Montana; and the form from the Cody shale (Upper Cretaceous) of Wyoming that Reeside[24] described and figured but did not name.

On the basis of the published illustrations and descriptions of the genotype accepted by us and all of the specimens, illustrations, and descriptions available, we have drawn up the following generic diagnosis: Conch nautiliconic and subglobular, and whorls, which are reniform in cross section, are broadly rounded ventrally and laterally and moderately deeply impressed dorsally. Aperture marked ventrally by a broad, shallow, rounded hyponomic sinus. Umbilicus small and inconspicuous; umbilical shoulders low and broadly rounded. Surface of conch smooth or essentially so. Septa moderately convex apicad and sutures of typical forms are slightly sinuous, but at least the external sutures of some forms are essentially straight. Typically each suture forms a broad, shallow lobe on the ventral and dorsal sides of the conch and on each of the umbilical walls, and these are separated by similar saddles; in some forms the lateral saddles are subdivided by very shallow lobes. A small dorsal (annular) lobe is present in some forms but not the genotype. Siphuncle small, circular in cross section, and orthochoanitic in structure; its position varies considerably in the different species but in no case is it marginal.

Hyatt states that there "are no annular lobes at any stage of development" in this genus, and Mojsisovics considered the presence or absence of annular lobes as an excellent systematic character. However, Foord[25] has demonstrated that in many species the annular lobe shows a tendency to become obsolete in the mature portion of the phragmacone, and both he and Spath[26] have concluded that this lobe is therefore of little taxonomic value. Spath[27] has stated that the annular lobe "may persist in forms that otherwise cannot be separated from *Eutre-*

[23] *Op. cit.*, pp. 496–498, pl. 27, figs. 1*a*–1*e*.

[24] Reeside, J. B., jr., Cephalopods from the lower part of the Cody shale of Oregon Basin, Wyoming: *U. S. Geol. Survey, Prof. Paper* 150A, p. 2, pl. 1, figs. 1–4, 1927.

[25] Foord, A. H., Catalogue of the fossil Cephalopoda in the British Museum (Natural History), part 2, p. 180, 1891.

[26] Spath, L. F., Revision of the Jurassic cephalopod fauna of Kachh (Cutch): *India Geol. Survey Mem.* (Palaeontologia Indica), new ser., vol. 9, mem. no. 2, p. 24, 1927.

[27] *Idem.*

phoceras"; this is precisely in accord with our findings, and such American forms as E. bryani (Gabb) show well developed annular lobes in the mature portion of the phragmacone and we have found them in an unnamed representative[28] of *Eutrephoceras* from the Pierre shale of Iron Butte, Montana.

The straight or only slightly sinuous sutures and the absence of nodes and spines serve to differentiate *Eutrephoceras* from other Mesozoic and Cenozoic genera. Some specimens that we are referring to *Cimomia* have only slightly sinuous sutures but they all have a rather well developed lateral saddle located just ventrad of the umbilical shoulder and their conchs are more nearly subdiscoidal than subglobular. However, differences in the suture pattern and ornamentation of the conch must be given far more weight than the general shape of the conch in the determination of the taxonomic position of a genus or species of nautiloid cephalopods, for it is now well known that in modern nautiloids there is a recognizable difference in the shape of the conchs of males and females of the same species; the lateral sides of the conchs of females are slightly flatter and more convergent, and those of the males are stouter and more gibbous. As pointed out by Spath,[29] a "classification of all these Nautili into *compressi* and *depressi*, as suggested by Frauscher,[30] would be highly artificial, especially in view of the proved sexual dimorphism; and the configuration of the septal surface is a far better systematic character."

EUTREPHOCERAS JONESI Miller and Thompson, n. sp.

Plate 34, figures 1, 2

A collection of Midway nautiloids that was kindly loaned us for study by the Alabama Museum of Natural History contains an essentially complete and remarkably well preserved internal mold that represents an unnamed species of the genus *Eutrephoceras*. We are proposing the name *Eutrephoceras jonesi* for it, in honor of Dr. Walter B. Jones, director of the Museum.

Conch large, subglobular in shape, and nautiliconic in its mode of growth. The whorls, being broadly rounded ventrally and laterally and moderately deeply impressed dorsally, are reniform in cross section. The holotype, which appears to be essentially complete adorally and to represent a mature individual, attained a maximum diameter, measured from the adoral end of the venter across the umbilicus to the opposite side of the specimen, of at least 225 mm.; the diameter at right angles to this and across the umbilicus measures about 150 mm. At the adoral end of the specimen, which is not far removed from the aperture, the maximum height and width of the conch measure about 130 mm.

[28] Paleontological collections of the State University of Iowa, Catalogue No. 614.

[29] Spath, L. F., On the classification of the Tertiary Nautili: *Annales Mag. Nat. Hist.*, ser. 9, vol. 20, p. 427, 1927.

[30] Frauscher, K. F., Nautilusse von Guttaring: *Kärnten Landesmus. Jahrb.*, vol. 23, p. 187, 1895.

and 170 mm., respectively, and the impressed zone is about 40 mm. deep and 70 mm. wide. At the adapical end of the outer volution the maximum height and width of the conch measure about 50 mm. and 70 mm. respectively. A comparison of these measurements with those taken at the adoral end of the specimen makes it obvious that the conch is expanded orad fairly rapidly. The living chamber is at least one-third of a volution in extent.

Umbilicus moderately small and not very prominent. Umbilical shoulders broadly rounded. Umbilical walls steep and slightly convex. The diameter of the umbilicus is equal to only about one-fourth the diameter of the conch, and the maximum diameter attained by the umbilicus of the holotype measures about 55 mm.

Surface of internal mold, at least, smooth and entirely devoid of markings other than the sutures. The sutures are directly transverse to the long axis of the conch and are essentially straight on the ventral and lateral sides of it, but they curve slightly but distinctly apicad in the region of the umbilical shoulders and each suture forms a broad, shallow, broadly rounded lobe as it crosses the umbilical wall. Unfortunately the internal sutures are not visible on the holotype and only known representative of this species. Camerae moderately short and along the venter the distance between successive sutures measures about one-fourth the width of the conch. The adoral four septa of the holotype are not well preserved but traces of them are very distinct in and near the umbilicus; they appear to be somewhat closer together than are the preceding ones, which indicates that the holotype represents a mature individual. The nature of the siphuncle of this species is not known as that of the holotype is not visible, but it is not ventral in position and presumably it is orthochoanitic in structure.

Remarks.—The large size, subglobular shape, and straight external sutures of this form distinguish it from other species. In so far as we have been able to ascertain it is so distinct from all described forms that specific comparisons would be superfluous.

Occurrence.—The above-described specimen was sent to us by the paleontologist of the Alabama Museum of Natural History as coming from the Midway; the label it bears indicates only that it came from Clarke County, Alabama. It is composed of grayish-white calcareous sandstone of a type with which unfortunately we are not familiar, so we can not give its precise horizon.

Repository.—Alabama Museum of Natural History, University, Alabama.

EXPLANATION OF PLATE 34

FIGS. 1, 2—*Eutrephoceras jonesi* Miller and Thompson, n. sp. Ventral and lateral views of the holotype, from Clarke County, Alabama, ×½.

1 2

Miller and Thompson, Eocene nautiloids

Genus CIMOMIA[31] Conrad

This genus was established by Conrad[32] in 1866 and only one species, *Nautilus burtini* Galeotti, was referred to it. This species then is the genotype; it was based by Galeotti[33] on an illustration, published by Burtin,[34] of a large nautiloid from the Eocene of Belgium. In as much as Burtin's publication has now become very rare and is not readily accessible to most paleontologists, we are reproducing Burtin's illustration; in order to make it conform with the page-size of this journal we are reducing it one-half linear, which makes it one-fourth the size of the specimen as it was already reduced one-half by Burtin. Unfortunately, a peripheral view of the specimen was not given, but we are inclined to agree with Foord[35] and Spath[36] that the venter of *Cimomia burtini* was most probably rounded.

The genus *Cimomia* has been overlooked by most students of Mesozoic and Tertiary nautiloids, but Spath[37] has recently taken cognizance of it and has reviewed it critically; he referred the following species to this genus: *Nautilus burtini* Galeotti, *N. imperialis* J. Sowerby, *N. lamarckii* Deshayes, *N. forbesi* d'Archiac and Haime, *N. mokattamensis* Foord, *N. leonicensis* de Zigno, *N. seelandi* Penecke, *N. landanensis* Vincent, *N. wyllei* Newton, and *Hercoglossa crassiconcha* Vogl, "not to mention such more doubtful forms as those described by Deshayes and Schafhäutl." It seems to us that the following American species are more closely related to *Cimomia burtini* than to any other genotype and should therefore be referred to the genus *Cimomia: Enclimatoceras vaughani* Gardner of the Midway of Texas, *Eutrephoceras haltomi* Aldrich of the Midway (Porters Creek clay = Sucarnochee clay) of Alabama, *Eutrephoceras haughti* Olsson of the upper Eocene (Saman formation) of Peru, the two forms from the Midway (Clayton formation) of Mississippi described below as *Cimomia vestali* and *C. subrecta*, and probably the specimen from the Eocene (Nanjemoy formation) of Maryland that Clark and Martin[38] erroneously in-

[31] Conrad spelled this name "*Cimomia*" early in 1866, "*Cymomia*" later in the same year, and "*Cimmomia*" in 1868; the original spelling is retained here.

[32] Conrad, T. A., Observations on Recent and fossil shells, with proposed new genera and species: *Amer. Jour. Conchology*, vol. 2, p. 102, 1866.

[33] Galeotti, M. H., Mémoire sur la constitution géognostique de la province de Brabant . . . : *Mém. couronnés par l'Acad. Roy. des Sci. et Bel.-Lettres de Bruxelles*, vol. 12, p. 140, 1837.

[34] Burtin, F.-X., Oryctographie de Bruxelles ou Description des fossiles tant naturels qu'accidentels découverts jusqu'a ce jour dans les environs de cette Ville, pp. 102–103, pl. 14, 1784.

[35] Foord, A. H., Catalogue of the fossil Cephalopoda in the British Museum (Natural History), part 2, p. 318, 1891.

[36] Spath, L. F., On the classification of the Tertiary Nautili: *Annales Mag. Nat. Hist.*, ser. 9, vol. 20, p. 425, 1927.

[37] *Op. cit.*, pp. 424–428.

[38] Clark, W. B., and Martin, G. C., *Maryland Geol. Survey*, Eocene, pp. 122–123, pl. 17, fig. 1, 1901; pl. 19, fig. 1 [not pl. 18, fig. 1]. Since this form is probably not even congeneric with the large specimen (pl. 18, fig. 1), which we are designating as the type of *Hercoglossa tuomeyi*, it is obviously desirable that a specific name be established for it, and we propose to call it *Cimomia marylandensis*. Its sutures are not nearly as strongly sinuous as are those of the type of *H. tuomeyi:* this is particularly noticeable in the case of the lateral lobes. Also, the lateral saddles of the

cluded in *Hercoglossa tuomeyi;* the specific name *Cimomia marylandensis* is proposed below for the form mentioned last. As is obvious from the species listed above, the genus *Cimomia* is widespread and is known to occur in Eurasia and Africa as well as in both North and South America; in America it appears to be limited to the Eocene, but in Europe it ranges up into the lower Oligocene.

On the basis of the reproduced illustration of the genotype, the specimens available for study, and the published illustrations and descriptions of the species listed above, we have drawn up the following generic diagnosis of *Cimomia:* Conch subglobular to subdiscoidal in shape and nautiliconic in its mode of growth. Whorls are broadly rounded laterally, rounded ventrally, and impressed dorsally. Umbilicus small; umbilical shoulders low and broadly rounded. Surface of conch smooth. Septa numerous and each suture forms a broad, shallow, broadly rounded ventral saddle; a broad, shallow, broadly rounded lateral lobe; a narrower, deeper, rounded lateral saddle, which is located near the umbilical shoulder; a broad, shallow lobe on the umbilical wall; a broad, shallow, broadly rounded saddle on the lateral side of the impressed zone; and a broad, shallow rounded dorsal lobe. Siphuncle small, circular in cross section, and orthochoanitic in structure; its position varies considerably in the different species, but it is in no case marginal.

Cimomia is perhaps more closely related to *Hercoglossa* than to any other described genus, and specimens which are more or less intermediate between these two genera are known from the Eocene of Maryland and Peru. However, typically *Hercoglossa* differs from *Cimomia* in that the sutures of the latter are much less strongly sinuous. This is particularly noticeable in the case of the ventral saddles and lateral lobes and the internal lobes and saddles, but the lateral saddles, though narrow, are fairly well developed in *Cimomia.* In certain respects *Cimomia* seems to be more or less intermediate between *Hercoglossa* and *Eutrephoceras;* its sutures are more strongly sinuous and typically its conch is more nearly subdiscoidal than is that of *Eutrephoceras.* The well developed lateral saddles of the sutures of *Cimomia* seem to us to be the feature by means of which representatives of the genus can be differentiated most readily from those of *Eutrephoceras,* but intermediate forms are known. In *Nautilus* s. s. the lateral lobes of the sutures are much deeper and the lateral saddles are shallower than in *Cimomia* (see text figure 2). Spath[39] has recently stated that the lateral ("umbilical") saddle in *Nautilus* s. s. is "much closer to the umbilicus than in *Cimomia";* this is true in some cases, but in the genotype of

two forms are markedly different. We are somewhat in doubt in regard to the generic affinities of *C. marylandensis* as it appears to us to be more or less intermediate between typical *Cimomia* and typical *Hercoglossa,* but its shallow lateral lobes and narrow, relatively well developed lateral saddles, indicate a relationship to the former genus.

[39] *Op. cit.,* p. 426.

EXPLANATION OF TEXT FIGURE 1

FIG. 1—*Cimomia burtini* (Galeotti), the genotype of *Cimomia*, $\times\frac{1}{4}$. Reproduction of the original illustration, reduced one-half linear (after Burtin).

Cimomia the lateral saddle is, if anything, closer to the umbilicus than in the genotype of *Nautilus* s. s. "*Nautilus*" *texanus* Shumard of the Lower Cretaceous (Washita) of Texas and the form from the Cretaceous of California that Gabb[40] erroneously referred to that species superficially appear to resemble typical *Cimomia* rather closely, but their conchs are annulated and their sutures are considerably different particularly in that the lateral saddle, which is located just ventrad of the umbilical shoulder, is relatively shallow, whereas in *Cimomia* it is well developed.

CIMOMIA VAUGHANI (Gardner)

Enclimatoceras vaughani GARDNER, *1923*, U. S. Geol. Survey, Prof. Paper 131, p. 115, pl. 33, fig. 1, and perhaps figs. 2, 3; *1932*, (in Trowbridge) U. S. Geol. Survey, Bull. 837, pl. 32, fig. 1, and perhaps pl. 33, figs. 1, 2.

Hercoglossa vaughani BERRY, *1923*, Amer. Jour. Sci., ser. 5, vol. 6, p. 429.

Eutrephoceras ? vaughani OLSSON, *1928*, Bull Amer. Paleontology, vol. 14, no. 52, p. 100.

This species was recently described by Gardner and two specimens were illustrated; since her publications are readily accessible to most paleontologists there is no need for us to duplicate this work. Unfortunately, none of the collections we are studying contains a representative of the species, and our concept of it is being based entirely on the published illustration of the large, nearly complete type [Gardner's figure 1. (1923)]; the sutures are not shown on the other specimen illustrated and we are therefore uncertain in regard to its affinities.

As shown by the synonomy, this species has been referred to several genera by different authors, but the very shallow ventral saddle and lateral lobe of its sutures and the well developed lateral saddle indicate clearly that its affinities are with *Cimomia*. However, it appears to be an aberrant member of that genus, and it is so distinct from all described forms that specific comparisons seem unnecessary.

Occurrence.—The type specimens of this species came from the Midway, near Frio River, Uvalde County, Texas.

CIMOMIA HALTOMI (Aldrich)

Eutrephoceras haltomi ALDRICH, *1931*, Alabama Mus. Nat. Hist., Mus. Paper 12, pp. 6, 7, pl. 1, fig. 1; pl. 2, fig. 1; pl. 3, figs. 1, 2.

This species was recently established by Aldrich and was based on three specimens all of which are incomplete and are more or less crushed; unfortunately the large specimen that was designated by Aldrich as the holotype is crushed almost beyond recognition and very little detailed information can be gleaned from it. Through the courtesy of the Director of the Alabama Museum of Natural History we have been able to restudy all of the type specimens, and in addition one of our collections contains a topotype; this latter specimen is not very complete but it is distinctly better than any of the primary types, and the accompanying diagrammatic text figures are based on it.

[40] Gabb, W. M., Description of the Cretaceous fossils: *California Geol. Survey*, Paleontology, vol. 1, p. 59, pl. 4, figs. 3*a*, 3*b*, 1864.

The topotype is an internal mold representing about half of the outer volution of the phragmacone. Growth-lines on portions of the test that adhere to this specimen indicate the presence of a broad, moderately deep hyponomic sinus on the rounded ventral side of the conch. Each suture is essentially straight as it crosses the ventral side of the conch but forms a broad, very shallow, broadly rounded lateral lobe; a relatively narrow, deep, rather narrowly rounded lateral saddle, which centers just ventrad of the umbilical shoulder; a broad, shallow, broadly rounded lobe on the umbilical wall; a broad rounded saddle on the lateral side of the impressed zone, centering on the dorsal portion of that lateral side; and a broad, shallow, broadly rounded dorsal lobe (see text figure 2). The siphuncle is orthochoanitic in structure. Most of the other characters of this species that are not obvious from the published illustrations are given by Aldrich.

Remarks.—The well developed lateral saddles of the sutures of this form indicate clearly that its affinities are with *Cimomia* rather than *Eutrephoceras*. The straight course of the ventral portion of the sutures serves to distinguish this species from all other described representatives of *Cimomia*. In *Cimomia subrecta* the ventral portion of each suture is nearly straight, forming only a very shallow, broadly rounded saddle, but the conch of that form is much narrower and therefore the cross section of the two species is markedly different.

Occurrence.—All of the specimens of this species known to us came from the Sucarnochee clay = Porters Creek clay (Midway) of Black Bluff, Alabama.

Repository.—Alabama Museum of Natural History, University, Alabama (holotype and paratypes); State University of Iowa, Catalogue No. 615 (topotype discussed above).

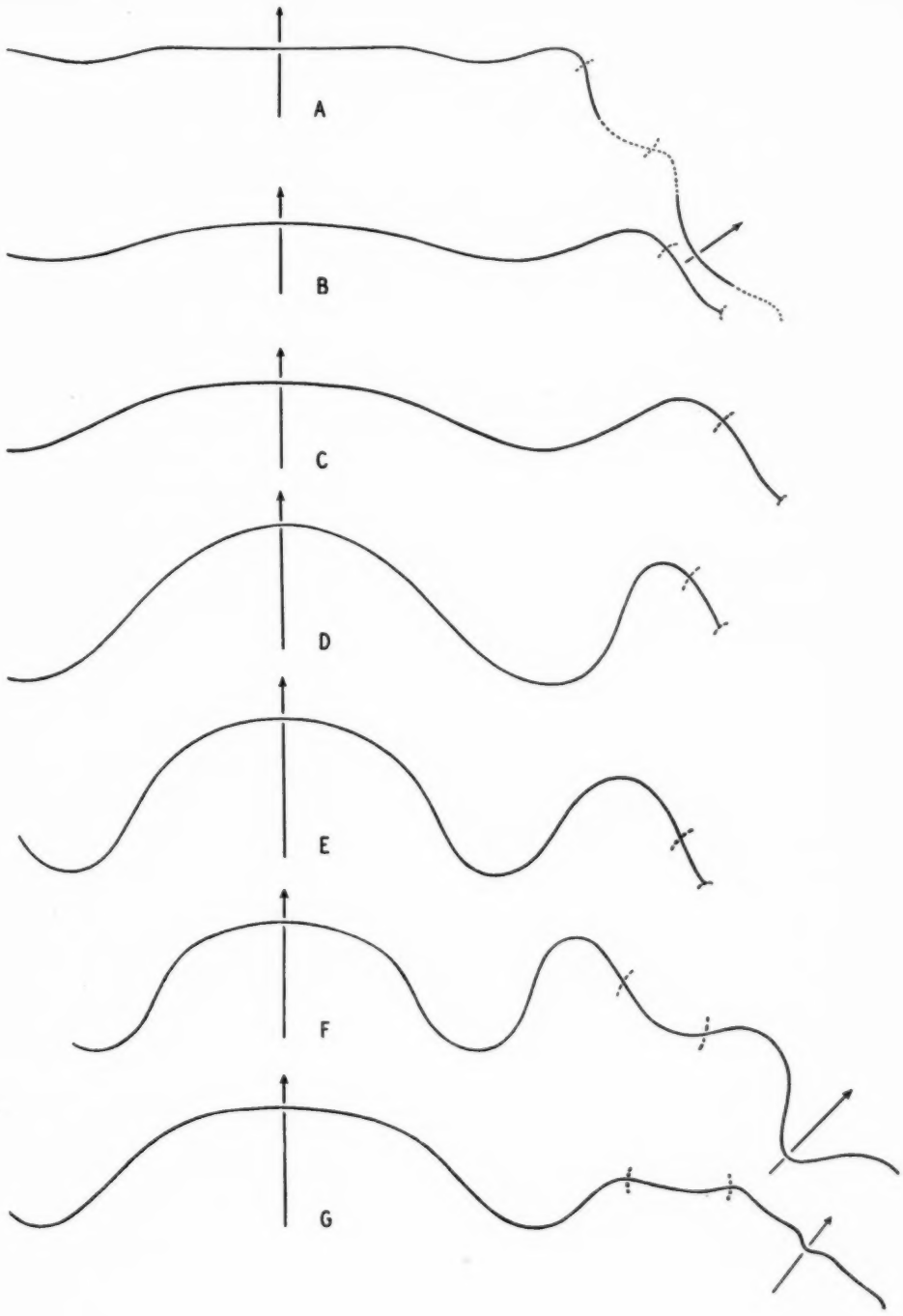
CIMOMIA SUBRECTA Miller and Thompson, n. sp.

Plate 35, figures 1, 2

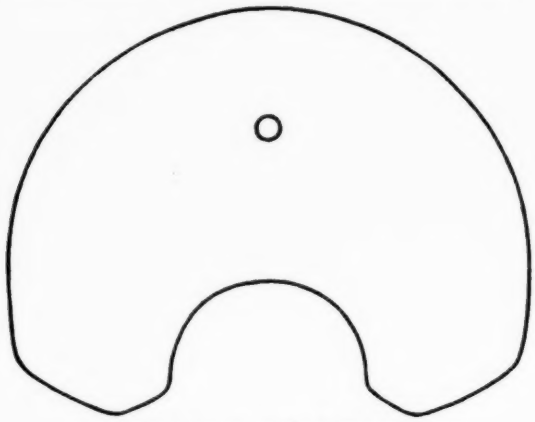
This species is being based on two moderately well preserved internal molds. One of them represents only the phragmacone but the other represents much of the living chamber as well as the phragmacone; the latter is designated as the holotype.

EXPLANATION OF TEXT FIGURE 2

FIG. 2—Diagrammatic representations of sutures of mature stages of
A, *Cimomia haltomi* (Aldrich), based on a topotype, ×¾;
B, *Cimomia subrecta* Miller and Thompson, based on the holotype, ×1;
C, *Cimomia vestali* Miller and Thompson, based on the holotype, ×1;
D, *Hercoglossa mcglameryae* Miller and Thompson, based on the holotype, ×¾;
E, *Hercoglossa ulrichi* (White), based on a specimen in the Alabama Museum of Natural History, from south-central Alabama, ×1;
F, *Hercoglossa orbiculata* (Tuomey), the genotype of *Hercoglossa*, based on the neoholotype, ×2/7;
G, *Nautilis pompilius* Linné, the genotype of *Nautilus*, based on an artificial internal mold made by filling the adoral camerae of a mature specimen with molten paraffin and then dissolving the calcareous test in hydrochloric acid, ×¾.


A
B
C
D
E
F
G

Conch nautiliconic in its mode of growth and subglobular in shape; it is moderately large but is much smaller than is typical for this genus. The holotype, which is essentially complete and represents a mature individual, attains a maximum diameter, measured from the adoral end of the venter across the umbilicus to the opposite side of the specimen, of about 130 mm.; the diameter at right angles to this and across the umbilicus measures about 90 mm. At the adoral end of the holotype, which does not represent the aperture though it apparently is not far removed from it, the maximum height of the conch measures about 75 mm.; the width of the conch can not be determined at this place due to imperfections of the specimen, but near the mid-length of the outer volution the height and width of the conch measure about 50 mm. and 65 mm., respectively. At the adapical end of the outer volution the height and width of the conch measure only about 30 mm. and 40 mm.; a comparison of these measurements with the figures given above shows that the conch is expanded orad fairly rapidly. The whorls are rounded ventrally, very broadly rounded laterally, and impressed dorsally; the depth of the impressed zone is equal to about one-third the height of the conch, and at the adoral end of the holotype the impressed zone is about 25 mm. deep and 40 mm. wide. Living chamber at least one-third of a volution in extent.



EXPLANATION OF TEXT FIGURE 3

FIG. 3—*Cimomia haltomi* (Aldrich). Diagrammatic cross section of conch showing shape of adoral portion of phragmacone and size and shape of siphuncle, ×1.

The umbilicus is small and inconspicuous; its diameter is equal to about one-fifth the diameter of the specimen, and the umbilicus of the

EXPLANATION OF PLATE 35

FIGS. 1, 2—*Cimomia subrecta* Miller and Thompson, n. sp. Lateral and ventral views of the holotype, from Clayton formation (basal Midway), 4½ miles south of Starkville, Mississippi, ×1.

1

2

Miller and Thompson, Eocene nautiloids

holotype attains a maximum diameter of about 25 mm. The umbilical shoulders are low and, though fairly definite, are rounded; they appear to become somewhat more prominent in the adoral portion of the conch.

The septa are sigmoidal in shape as their ventral portion is curved adorally and their dorsal portions (on either side of the impressed zone) are curved adapically. The camerae are moderate in length and along the venter the distance between successive sutures is normally equal to about two-sevenths the width of the conch, but in the adoral portion of the phragmacone of both of the types the septa are closely spaced which indicates that the specimens represent mature individuals. Surface of internal mold, at least, smooth and entirely devoid of markings other than the sutures. Each suture forms a broad, very shallow, broadly rounded lateral lobe; a deeper, narrower lateral saddle, which centers slightly ventrad of the umbilical shoulder; a broad, shallow, rounded lobe on the umbilical wall; a broad, shallow, broadly rounded saddle on the lateral side of the impressed zone; and a broad, shallow, rounded dorsal lobe (see text figure 2).

Siphuncle small, circular in cross section, and subventral in position. At the adoral end of the paratype, where the maximum height of the conch is about 60 mm., the siphuncle is about 3.5 mm. in diameter and its center is located about 15 mm. from the venter. As in other members of this genus, the siphuncle is orthochoanitic in structure, though the septal necks are not very long.

Remarks.—This species appears to be more nearly similar to *Cimomia vestali* and *C. haltomi* than to any other described species. At maturity it is considerably smaller than mature representatives of *C. vestali*, its conch is distinctly narrower and is more broadly rounded ventrally, and its sutures are less strongly sinuous. The conch of *C. haltomi* is much wider and more broadly rounded ventrally, and at least its external sutures are much more nearly straight.

Occurrence. — Clayton formation (basal Midway), E. ½, sec. 28, T. 18 N., R. 14 E., that is, 4½ miles south of Starkville, Mississippi (holotype); and 3 miles west of Starkville, Mississippi (paratype).

Repository.—State University of Iowa, Catalogue Nos. 618 (holotype) and 619 (paratype).

CIMOMIA VESTALI Miller and Thompson, n. sp.
Plate 36, figures 1, 2

Two well preserved internal molds in one of the collections we are studying represent an undescribed species of *Cimomia* for which we are proposing the specific name *Cimomia vestali*, in honor of Mr. F. E. Vestal of Mississippi State College, who collected one of the specimens. The larger of the types represents most of the living chamber as well as the phragmacone, but the other represents only the phragmacone; nevertheless we are designating the latter as the holotype for it shows the size and position of the siphuncle as well as the nature of the sutures.

Conch subglobular in shape and

nautiliconic in its mode of growth. Whorls are narrowly rounded ventrally, very broadly rounded laterally, and impressed dorsally. The holotype represents most, if not all, of the phragmacone of a mature individual; its maximum diameter, measured from the adoral end of the venter across the umbilicus to the opposite side of the specimen, measures about 125 mm.; the diameter at right angles to this and across the umbilicus measures about 90 mm. At the adoral end of the holotype the maximum height of the conch measures about 80 mm. and the maximum width about 90 mm. (estimated), and the dorsal side of the conch is impressed to a depth of about 30 mm. At the adapical end of the outer volution of this specimen the maximum height and width of conch measure only about 30 mm. and 40 mm., respectively, from which it is obvious that the conch is expanded orad fairly rapidly. Living chamber at least one-third of a volution in extent. At adoral end of paratype, which does not represent the aperture, though it apparently is not far removed from it, the maximum height and width of the conch measure about 95 mm. and 110 mm. (estimated), respectively; this specimen also represents a mature individual and it attains a maximum diameter, measured from the adoral end of the venter across the umbilicus to the opposite side of the specimen, of about 175 mm.

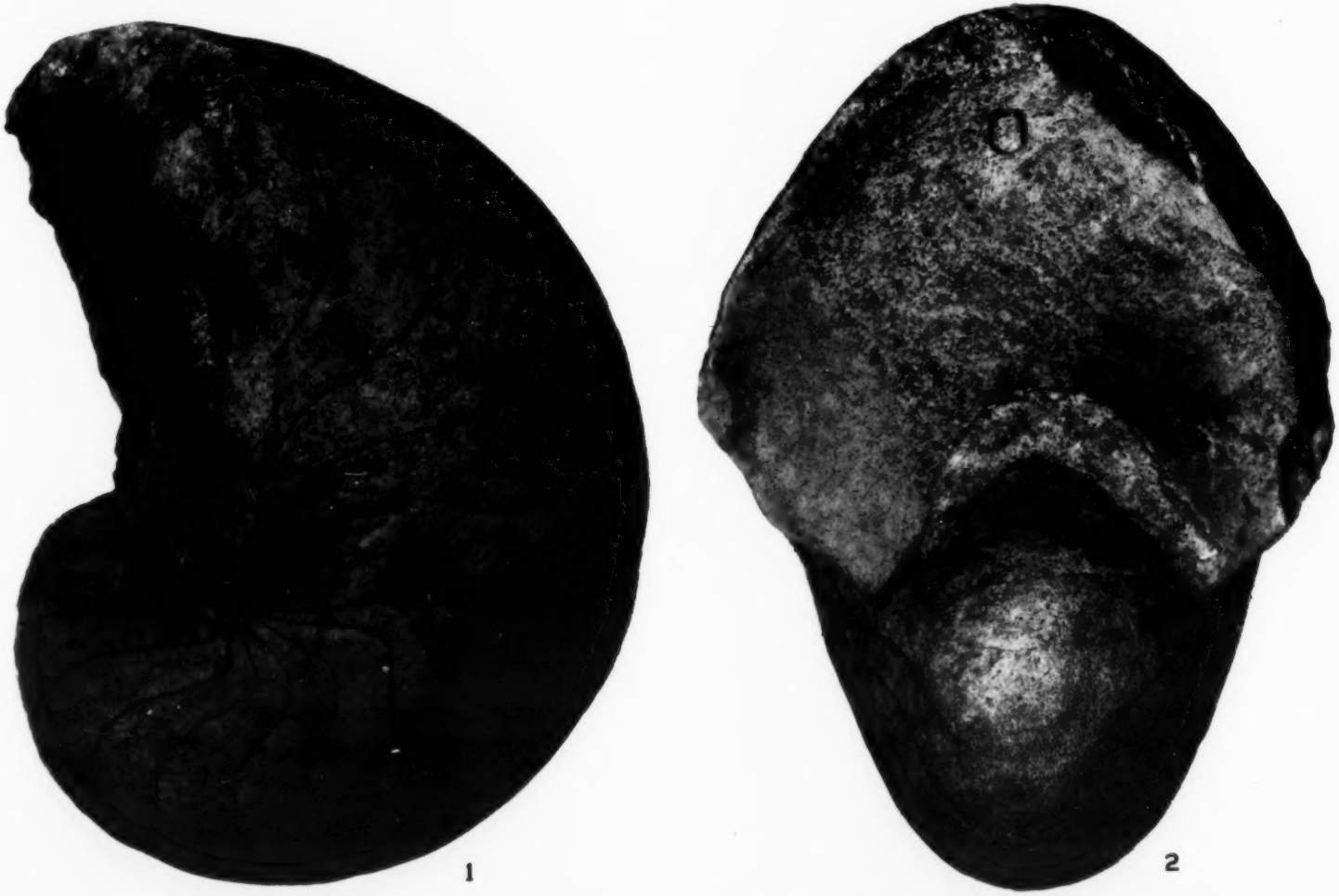
Umbilicus small and inconspicuous; that of holotype attains a maximum diameter of about 25 mm., whereas that of paratype attains a diameter of about 35 mm. Umbilical shoulders low and rounded. Umbilical walls convex.

Septa moderately closely spaced and more or less sigmoidal as their ventral portion is curved adorally whereas their dorsal portion is curved adapically. Along the venter the distance between successive sutures normally measures about one-third the maximum width of the conch, but in both of the types the adoral septa are more closely spaced than are the preceding ones, which indicates that both specimens represent mature individuals. Surface of internal mold, at least, smooth and entirely devoid of markings other than the sutures. Each suture forms a very broad, shallow, broadly rounded ventral saddle; a similar but much narrower lateral lobe; a deeper, narrower lateral saddle, which centers slightly ventrad of the umbilical shoulder; a broad, shallow, broadly rounded lobe on the umbilical wall; a broad, shallow, broadly rounded saddle on the lateral side of the impressed zone; and a broad, shallow, rounded dorsal lobe (see text figure 2).

Siphuncle small, circular in cross section, and subventral in position.

EXPLANATION OF PLATE 36

FIGS. 1, 2—*Cimomia vestali* Miller and Thompson, n. sp. Lateral and ventral views of the holotype, from Clayton formation (basal Midway), east bluff of Trim Cane Creek, about 3 miles west and a little north of Starkville, Mississippi, ×1.



1 2

Miller and Thompson, Eocene nautiloids

At the adoral end of the holotype, the siphuncle is about 5 mm. in diameter and its center is located about 16 mm. from the venter. It is orthochoanitic in structure.

Remarks.—Certain slight differences in the general shape of the conchs of the holotype and the paratype can be discerned, but these are probably due to a slight amount of distortion that both have obviously undergone during preservation, or to sexual dimorphism, and they should not be taken to mean that the two specimens represent different species.

This species is perhaps more nearly similar and presumably therefore more closely related to *Cimomia subrecta* than to any other described species, but it differs from that form in that its conch is larger, is slightly wider, and is more narrowly rounded ventrally, and its sutures are more strongly sinuous.

Occurrence.—Clayton formation (basal Midway), east bluff of Trim Cane Creek, about 3 miles west and a little north of Starkville, Mississippi (holotype); and southwest bluff of Yellow Creek, sec. 7, T. 15 N., R. 16 E., that is, about 9 miles northwest of Macon, Mississippi (paratype).

Repository.—State University of Iowa, Catalogue Nos. 616 (holotype) and 617 (paratype).

Genus Hercoglossa Conrad

At the same time that Conrad[41] established *Cimomia*, he also established *Hercoglossa* and referred to it three species, *Nautilus orbiculatus* Tuomey, *Aturia mathewsonii* Gabb, and *Nautilus parkinsoni* Edwards. Conrad obviously intended the first of these species to be the genotype, and in 1883 Hyatt[42] designated it as such. Spath[43] has recently listed *Nautilus danicus* Schlotheim as the genolectotype; we doubt very much the value of "genolectotypes" and wish to point out that they are likely to be confused with valid genotypes by even such careful workers as Spath.[44]

Aturia mathewsonii and *Nautilus parkinsoni* are not closely related to *Hercoglossa orbiculata* and in our opinion they are not congeneric with it; the former should be left in the genus *Aturia* and Spath[45] has recently made the latter the type of a new genus *Paraturia*, which apparently is to be suppressed as a synonym of *Aturoidea* Vredenburg.[46] However, representatives of the genus *Hercoglossa* are widespread in the Upper Cretaceous and Eocene of Europe, Asia, and Africa. Spath[47] has recently "provisionally retained in this genus *Hercoglossa*" the Upper Jurassic forms "of the type of *N.*

[41] Conrad, T. A., Observations on Recent and fossil shells, with proposed new genera and species: *Amer. Jour. Conchology*, vol. 2, pp. 101–102, 1866.

[42] Hyatt, Alpheus, Genera of fossil cephalopods: *Boston Soc. Nat. Hist., Proc.*, vol. 22, p. 270, 1883.

[43] Spath, L. F., Revision of the Jurassic cephalopod fauna of Kachh (Cutch): *India Geol. Survey Mem.* (Palaeontologia Indica), new ser., vol. 9, mem. no. 2, p. 22, 1927.

[44] *Op. cit.*, p. 19.

[45] *Op. cit.*, pp. 22, 26.

[46] Vredenburg, E., Descriptions of Mollusca from the post-Eocene Tertiary formation of north-western India; Cephalopoda, Opisthobranchiata, Siphonostomata: *India Geol. Survey, Mem.* 50, p. 9, 1928.

[47] *Op. cit.*, pp. 25–26.

franconicus Oppel and *N. oppeli* Zittel," but he recognized that they "probably form an independent development"; the ventral saddle of the sutures of both of the species cited is divided by a distinct median lobe which clearly differentiates them generically from *Hercoglossa*. However, *Nautilus stromeri* Loesch[48] of the Upper Jurassic of Czechoslovakia externally resembles typical *Hercoglossa* rather closely, but it doubtlessly represents a distinct genus and its internal sutures are probably markedly different. In North America representatives of *Hercoglossa* are not known to occur in strata older than the Midway, and in our opinion the North American species that are referable to this genus are the following: *Nautilus orbiculatus* Tuomey, *Enclimatoceras* (*Nautilus*) *ulrichi* White, and *Hercoglossa mcglameryae* Miller and Thompson, n. sp., of the Midway of the Gulf Coastal Plain; *H. tuomeyi* Clark and Martin s. s. of the Eocene (Pamunkey group) of Maryland; and *H. merriami* Dickerson of the lower Eocene (Martinez formation) of California. *H. peruviana* Berry of the Restin sandstone (middle Eocene) of northwestern Peru appears to be more or less intermediate between typical *Hercoglossa* and typical *Cimomia*, but it probably should be left in *Hercoglossa*. The specimen from the same horizon and locality that Olsson[49] figured and referred to this species is a typical representative of *Hercoglossa* but it clearly is specifically distinct from the type of *H. peruviana* and we propose to call it *H. restinense;* the wider lateral saddles and the narrower, deeper lateral lobes of its sutures serve to distinguish it from typical *H. peruviana* and its short camerae and the general shape of its sutures differentiate it from *H. ulrichi*.

On the basis of the specimens we are studying, including a topotype of the genotype, and the numerous illustrations and descriptions available, we have drawn up the following generic diagnosis of *Hercoglossa:* Conch nautiliconic in its mode of growth and subdiscoidal in form. Whorls more or less flattened (but typically very broadly rounded) laterally, narrowly rounded ventrally, and deeply impressed dorsally. Umbilicus small. Surface of conch smooth. Septa numerous and each suture forms a broad, broadly rounded ventral saddle; a broad, deep rounded lateral lobe; a similar lateral saddle; a broad, very shallow rounded lobe on or near the umbilical wall, a broad, fairly deep saddle on the lateral side of the impressed zone; and a broad, moderately deep, narrowly rounded dorsal lobe. Siphuncle small and orthochoanitic in structure; its position varies considerably in the different species but it is in no case marginal.

Hercoglossa is perhaps more closely related to *Cimomia* than to any other described genus, and specimens which are more or less intermediate be-

[48] Loesch, K. C. von, Die Nautilen des weissen Jura; Part 1: *Palaeontographica*, Bd. 61, pp. 124–125, pl. 13(4), figs. 5*a*, 5*b*, 1914.

[49] Olsson, A. A., Contributions to the Tertiary paleontology of northern Peru; Part 1, Eocene Mollusca and Brachiopoda: *Bull. Amer. Paleontology*, vol. 14, no. 52, p. 96, pl. 23, fig. 1, 1928.

tween these two genera have been described from the Eocene of Maryland and Peru. However, typically *Hercoglossa* differs from *Cimomia* in that the sutures of the latter are much less strongly sinuous; this is particularly noticeable in the case of the ventral saddles and the lateral lobes and the lobes and saddles of the internal sutures, for the lateral saddles are fairly well developed in *Cimomia* (see text figure 2). In certain respects *Cimomia* seems to be intermediate between *Hercoglossa* and *Eutrephoceras*. *Hercoglossa* differs from *Nautilus* s. s. in that the lateral saddles of its external sutures and all of the lobes and saddles of its internal sutures are much more strongly developed. As a matter of fact, the internal sutures of *Nautilus* s. s. are nearly straight but they are marked centrally by a miniature (annular) lobe (see text figure 2).

As is now generally recognized, *Enclimatoceras* Hyatt[50] [genotype *Enclimatoceras* (*Nautilus*) *ulrichi* White] is to be regarded as a synonym of *Hercoglossa* Conrad.

HERCOGLOSSA ORBICULATA (Tuomey)
Plate 37, figures 1, 2

Nautilus orbiculatus TUOMEY, *1856*, Philadelphia Acad. Nat. Sci., Proc., vol. 7, pp. 167–168.

Hercoglossa orbiculata CONRAD, *1866*, Amer. Jour. Conchology, vol. 2, p. 101.

This species was originally described by Tuomey as follows:

Shell somewhat discoid, thick in the centre and gradually thinner towards the circumference; last chamber very large, spreading at the umbilicus; siphunculus nearly central; septa profoundly undulating, showing on the back a sharp recurved lip.

This is the largest of the genus found in our rocks, being ten inches in diameter. It resembles quite closely *N. danicus*[51], especially in the undulations of the septa.

Locality, Alabama.

No illustration accompanies this entirely inadequate description, and Tuomey states that these "brief characters are given in advance of more full descriptions, with figures, that may follow hereafter." A final report was never published however, and unfortunately the type has since been lost and to date no additional representatives of the species have been described.[52]

Since this species has been made the type of a genus, *Hercoglossa*, it is more than ordinarily desirable that a detailed diagnosis of it be available; unless the original type can be found (which seems very improbable) such a diagnosis should be based on only a topotype. Unfortunately Tuomey states only that his type came from Alabama, but the title of his paper

[50] Originally described by Hyatt, Alpheus, Genera of fossil cephalopods: *Boston Soc. Nat. Hist., Proc.*, vol. 22, p. 270, 1883.

[51] This species was founded in 1820 by Schlotheim (Die Petrefactenkunde . . . , p. 83) and was based on specimens that came from the Danian of "Faxöe und mehrern dänischen Inseln"; his description is very brief and generalized and is not accompanied by an illustration. However, Lyell (*Geol. Soc. London Trans.*, ser. 2, vol. 5, p. 250, pl. 18, figs. 4–7, 1837) and Ravn (*Mus. Min. et Géol. l'Univ. Copenhague*, Comm. Pal., no. 2, pp. 242–246, pl. 4, figs. 3–4; pl. 5, fig. 3, 1902) have figured well preserved topotypes from Faxe that show clearly the general form of the conch, the shape of both the internal and the external sutures, and the size and position of the siphuncle.

[52] Whitfield (*U. S. Geol. Survey, Mon.* 18, p. 246) considered the possibility that *Aturoidea* ["*Hercoglossa*"] *paucifex* (Cope) was the same as *Hercoglossa orbiculata*, but concluded that this was not the case; we agree with his conclusion.

indicates that it came from the "Cretaceous" of that state; however, at the time Tuomey wrote this paper the basal part of the Midway, including the so-called "Nautilus (Enclimatoceras) Rock," was included with the Cretaceous.[53] Shortly before the publication of Tuomey's paper the "Midway beds about Allenton, Ala., and 'eight and a half miles to the north' of that place were studied . . . by Prof. A. Winchell. . . . The fossils he collected were placed in the hands of Prof. Tuomey for description. . . ."[54] It seems very probable that one of these specimens formed the basis for Tuomey's description of *Hercoglossa orbiculata* and that that specimen came from north of Allenton, Alabama. In so far as we have been able to ascertain, the only horizon there in which representatives of the genus *Hercoglossa* [=*Enclimatoceras*] are known to occur is the so-called "Nautilus (Enclimatoceras) Rock," which is located stratigraphically near the base of the Midway.

During the 1931 summer season the junior author of the present paper, in company with Mr. F. E. Vestal of Mississippi State College, collected a large nautiloid from an outcrop of the basal Midway ["Nautilus (Enclimatoceras) Rock"] about 5 miles north of Allenton, Alabama, on Pine Barren Creek. This specimen seems to conform with Tuomey's description, and since it came from what we believe to be the same horizon and the same general locality as that which yielded Tuomey's type specimen, there is no good reason to doubt that the two are conspecific; we propose to regard this specimen as a neotype, though we are aware of the fact that the significance of neotypes is open to question.

On the basis of this neoholotype, we have drawn up the following specific description: Conch, which apparently consists of several volutions, is large, subdiscoidal in form, and nautiliconic in its mode of growth. The neoholotype, a well preserved internal mold representing three (and part of two more) of the adoral camerae of the phragmacone, was somewhat larger than Tuomey's type for the chambered portion of this shell attained a maximum diameter (measured from the extreme adoral end of the venter across the umbilicus to the opposite side of the specimen) of about 11 inches (estimated). The two adoral camerae of this specimen are considerably shorter than the preceding ones, which indicates that the specimen represents a mature or gerontic individual, and this may account for the fact that the specimen is somewhat larger than the original

[53] Smith, E. A., and Johnson, L. C., Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee, and Alabama rivers: *U. S. Geol. Survey, Bull.* 43, pp. 65–66, 1887.

[54] Harris, G. D., The Midway stage: *Bull. Amer. Paleontology*, vol. 1, no. 4, p. 7, 1896.

EXPLANATION OF PLATE 37

FIGS. 1, 2—*Hercoglossa orbiculata* (Tuomey). Lateral and ventral views of the neoholotype, from Clayton formation (basal Midway). on Pine Barren Creek, about 5 miles north of Allenton, Alabama, ×½.

1 2

Miller and Thompson, Eocene nautiloids

type; it also indicates that it is the extreme adoral portion of the phragmacone that is represented by the neoholotype.

The conch is flattened laterally and the whorls are subtrigonal in cross section (impressed zone disregarded) as the nearly flat (slightly convex exteriorly) lateral sides converge toward the rather narrowly rounded venter and the umbilical shoulders are rather abrupt and the umbilical walls fairly steep. The maximum width of the conch, which is attained just ventrad of the umbilical shoulders, is almost equal to the maximum height. At the adapical end of the neoholotype the maximum width of the conch measures about 135 mm. and the maximum height about 140 mm.; at the adoral end of this specimen these measurements are about 160 mm. and 170 mm., respectively. These figures indicate that the conch expands orad fairly rapidly for the preserved part of the neoholotype represents only about one-third of a volution.

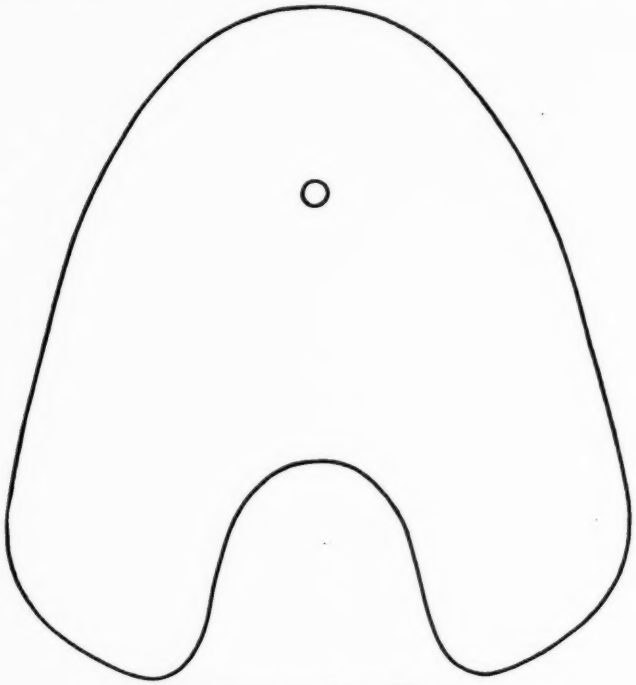
Dorsal side of conch is impressed by ventral portion of preceding volution; maximum depth of impressed zone is equal to slightly more than one-third height of conch, and maximum width is equal to slightly less than one-half maximum width of conch. The lateral sides of the impressed zone are nearly straight (slightly concave) and the ventral side is rather narrowly rounded. The junctions of the umbilical walls with the lateral sides of the impressed zone are narrowly rounded. The impressed zone of the neoholotype attains a maximum depth of about 65 mm. and width of about 75 mm. at the adoral end of the specimen.

Umbilicus small and probably imperforate. Umbilical shoulders rounded but fairly distinct. Umbilical walls nearly straight (slightly convex) and inclined to the nearly flat lateral sides of the conch at an angle of about 115 degrees. Diameter of umbilicus equal to about one-sixth (estimated) diameter of specimen.

Surface of internal mold, at least, smooth and entirely devoid of markings other than the sutures. Sutures very sinuous, and each suture forms a large, broad, deep, very broadly rounded ventral saddle; a narrower (but nevertheless very broad), rather narrowly rounded, asymmetrical lateral lobe; a somewhat narrower and more narrowly rounded lateral saddle, located on the dorsal half of the conch; a broad, rounded, asymmetrical dorso-lateral lobe, which centers on the umbilical wall just outside the umbilical seam; a broad, broadly rounded, asymmetrical saddle, located on the lateral side of the impressed zone; and a broad, rather narrowly rounded, median dorsal lobe (see text figure 2). The camerae of this form are moderate in length. Along the venter the distance between successive sutures is equal to almost one-half the maximum width of the conch, but in the adoral portion of the neoholotype the septa are relatively closely spaced; as mentioned above, this indicates that the specimen represents a mature or gerontic individual. Along both flanks of the lateral lobe the distance be-

tween successive sutures is markedly decreased; this character is more strongly developed along the dorsal than along the ventral flank. The septa are only slightly concave transversely, but they are rather strongly sigmoidal dorso-ventrally as their ventral portion is curved strongly orad and their dorsal portion is curved apicad.

Siphuncle rather small, circular in cross section, and apparently orthochoanitic in structure. Due to the large size of the impressed zone the siphuncle appears to be located only slightly ventrad of the center of the conch, but measurements show that it is located approximately midway between the center and the venter. At the adapical end of the neoholotype the siphuncle is about 8 mm. in diameter at its passage through a septum, and it is located about 35 mm. from the venter and about 50 mm. from the bottom of the dorsal impressed zone, or about 100 mm. from the extreme dorsal portion of the conch.



EXPLANATION OF TEXT FIGURE 4

FIG. 4—*Hercoglossa orbiculata* (Tuomey). Diagrammatic cross section of conch, showing shape of adoral portion of phragmacone and size and position of siphuncle of neoholotype, ×½.

Remarks.—This species is more nearly similar to *Hercoglossa ulrichi* (White) and *H. danica* (Schlotheim) than to any other described forms, but it is considerably larger than either of them, its siphuncle is much

less nearly central in position, and its sutures present certain differences. In *H. ulrichi* both the lateral saddles and the lateral lobes of the sutures are distinctly shallower and more broadly rounded than are those of *H. orbiculata*. In *H. danica* the lateral lobes are distinctly narrower than the lateral saddles, whereas in *H. orbiculata* the reverse is the case. *H. tuomeyi* Clark and Martin s. s. is as large as *H. orbiculata* but its camerae are shorter and its sutures are markedly different; at least all of the external lobes and saddles of its sutures are shorter and more broadly rounded, and the septa are not crowded on the ventral flanks of the lateral lobes as they are in *H. orbiculata*.

In his description of the original type of this species, Tuomey states that the living chamber is "very large, spreading at the umbilicus." Unfortunately, no portion of the living chamber is represented by the preserved part of the neoholotype, but presumably the "spreading at the umbilicus" of the extreme adoral portion of the conch of this species is comparable to that which occurs in such closely related forms as *H. ulrichi* (see U. S. Geol. Survey, Bull. 4, plates 8, 9).

Occurrence.—The neoholotype came from the Clayton formation (basal Midway), about 5 miles north of Allenton, Alabama, on Pine Barren Creek. Presumably the holotype came from the same general horizon and locality.

Repository.—State University of Iowa, Catalogue No. 612 (neoholotype).

HERCOGLOSSA ULRICHI (White)

Nautilus texanus WHITE [not SHUMARD], *1882*, U. S. Nat. Mus., Proc., vol. 4, p. 137.
Enclimatoceras ulrichi [WHITE] HYATT, *1883*, Boston Soc. Nat. Hist., Proc., vol. 22, p. 270.
Enclimatoceras (*Nautilus*) *ulrichi* WHITE, *1884*, U. S. Geol. Survey, Bull. 4, pp. 16–17 pl. 7, figs. 1–3; pl. 8, fig. 1; pl. 9, fig. 1.
(?) *Enclimatoceras hyatti* ? [WHITE] ALDRICH, *1886*, Alabama Geol. Survey, Bull. 1, p. 60.
Hercoglossa ulrichi FOORD and CRICK, *1890*, Annals and Mag. Nat. Hist., ser. 6, vol. 5, p. 392.
Enclimatoceras (*Nautilus*) *ulrichi* HARRIS, *1894*, Arkansas Geol. Survey, Ann. Rep. for 1892, pp. 36–39, pl. 2, figs. 1–3.
Enclimatoceras ulrichi HARRIS, *1896*, Bull. Amer. Paleontology, vol. 1, no. 4, pp. 122–125, pl. 13, figs. 1–3, pl. 14, fig. 1; pl. 15, fig. 1.
Hercoglossa (*Enclimatoceras*) *ulrichi* GRABAU and SHIMER, *1910*, North Amer. Index Fossils, vol. 2, pp. 111–112, text fig. 1343.
Enclimatoceras ulrichi DEUSSEN, *1914*, U. S. Geol. Survey, Water-Supply Paper 335, pl. 3, figs. 1–1*b*; *1924*, U. S. Geol. Survey, Prof. Paper 126, p. 41, pl. 14, figs. 1*a*, 1*b*.

This species was originally described by White, though Hyatt's description of the genus that was founded for it and related forms actually appeared in print first. White's description is accompanied by five excellent figures which have been reproduced by Harris; these are readily accessible to most paleontologists and since they show clearly the general shape of the conch, the nature of the sutures, and the size and position of the siphuncle, it is not necessary for us to duplicate this work. However, White did not investigate the structure of the siphuncle and he did not point out the characters that distinguish this species from closely related forms.

White's figures show the siphuncle of this species to be small, circular in cross section, and located almost midway between the venter and the

bottom of the impressed zone or slightly less than three-sevenths of the distance from the venter to the extreme dorsal portion of the conch; in some of the specimens that we are referring to this species the siphuncle is somewhat nearer the venter. A longitudinal section of a typical representative[55] of this species from the Clayton formation (basal Midway) near Allenton, Alabama, shows that the septal necks are straight and moderately long (about one-sixth as long as the camerae), and the connecting rings are only slightly expanded within the camerae; the segments of the siphuncle are therefore essentially cylindrical in shape and the siphuncle is orthochoanitic in structure.

This species seems to be more closely similar and therefore presumably more closely related to *Hercoglossa orbiculata* (Tuomey), *H. danica* (Schlotheim) and *H. mcglameryae* Miller and Thompson than to any other described forms. *H. orbiculata* is a much larger form and the lateral saddles and lateral lobes of its sutures are distinctly deeper and more narrowly rounded than are those of *H. ulrichi* (see text figure 2). *H. mcglameryae* is very similar in general aspect to *H. ulrichi* but differs from it in that its conch is somewhat more strongly compressed laterally, and its sutures present certain differences. In *H. mcglameryae* the lateral saddles of the sutures are much narrower than are those of *H. ulrichi* and the lateral lobes are correspondingly wider, more broadly rounded, and more strongly asymmetrical (see text figure 2). These two species can also be differentiated by the relative lengths of the different portions of the camerae. In *H. mcglameryae* adjacent sutures are slightly closer together along the venter than in *H. ulrichi;* the sutures of *H. mcglameryae* are almost as far apart along the ventral flank of the lateral lobes as near the center of those lobes, but they are very close together along the dorsal flank of the lateral lobes.

Scott[56] has recently maintained that *H. danica* and *H. ulrichi* are identical, but Gardner[57] has denied their identity and Douvillé[58] states merely that *H. ulrichi* "n'est pas sans analogies avec le *Nautilus danicus*." As is well known the empty shells of modern nautiloids drift widely after the death and decay of the animals that secrete them—the three living species of *Nautilus* are confined to the moderately shallow waters of the South Pacific from the Malay region to the Philippine and the Fiji Islands, but their empty shells drift to such remote places as Japan, Africa, and New South Wales. During Midway time the Floridian Peninsula did not exist but there must have been a current across the North Atlantic,

[55] State University of Iowa, Catalogue No. 613.

[56] Scott, Gayle, Études stratigraphiques et paléontologiques sur les terrains crétacés du Texas: Thesis, Université de Grenoble, pp. 114–118, 1926; On a new correlation of the Texas Cretaceous: *Amer. Jour. Sci.*, ser. 5, vol. 12, pp. 157–161, 1926.

[57] Gardner, Julia, On Scott's new correlation of the Texas Midway: *Amer. Jour. Sci.*, ser. 5, vol. 12, pp. 453–455, 1926.

[58] Douvillé, H., La Cardita Beaumonti en Amérique: *Compte Rendu Sommaire des Séances Soc. géol. France*, 1929, Fascicule 12, p. 167, 1929.

comparable to the present Gulf Stream, and it could have transported floating shells and animals from the Midway Sea of the Gulf Coastal Region to Baltic Europe. If then, as was contended by Scott,[59] the Danian and the lower part of the Midway are essentially time equivalents, it might readily be possible for the same species of nautiloid cephalopod to be represented in each. However, it is generally believed that the Danian is somewhat older than the Midway, and as is shown below *H. ulrichi* is not identical with *H. danica*.

The original description of *H. danica* is by Schlotheim[60]; it is very brief and generalized and is not accompanied by an illustration. However, Schlotheim states that he based the species on specimens from "Faxöe und mehrern dänischen Inseln." Lyell,[61] Blanford,[62] Moberg,[63] Foord and Crick,[64] and Ravn[65] have all figured specimens which they referred to this species. It seems to us very doubtful if all of these are conspecific—they came from various localities in Europe and Asia—and we are therefore basing our conception of *H. danica* on the figures given by Lyell and Ravn, for they are based on specimens that came from Faxe, i.e., topotypes, and they appear to be carefully executed.[66] It is obvious from a comparison of these figures with specimens and illustrations of *H. ulrichi* that the two species, though superficially similar, are quite distinct; the general shape of the conch of the two is not the same and the sutures present significant differences. The conch of *H. ulrichi* appears to be narrower and more narrowly rounded ventrally than is that of *H. danica*. In *H. danica* the lateral lobes of the sutures are distinctly narrower than the lateral saddles, whereas in *H. ulrichi* (as in *H. orbiculata*) the reverse is the case; also it would appear from the available evidence (which is rather limited) that *H. ulrichi* attained a much larger size than did *H. danica*.

Occurrence.—The type specimens of *H. ulrichi* came from near Little Rock, Arkansas, presumably from the basal Midway; specimens from various localities in Arkansas, Texas, Tennessee, Mississippi, and Alabama have been referred to this species by

[59] *Op. cit.*

[60] Schlotheim, E. F. Baron von, Die Petrefactenkunde . . . , p. 83, 1820.

[61] Lyell, Charles, On the Cretaceous and Tertiary strata of the Danish islands of Seeland and Moen: *Geol. Soc. London, Trans.*, ser. 2, vol. 5, p. 250, pl. 18, figs. 4–7, 1837.

[62] Blanford, Henry F., The fossil Cephalopoda of the Cretaceous rocks of southern India (Belemnitidae-Nautilidae): *India Geol. Survey, Mem.* (Palaeontologia Indica), pp. 24–25, pl. 10, fig. 4; pl. 11, figs. 1, 2, 1865.

[63] Moberg, J. C., Cephalopoderna i Sveriges Kritsystem: *Sveriges geol. Undersokning*, ser C, no. 73, II, pp. 11–13, pl. 1, figs. 7–12, 1885.

[64] Foord, Arthur H., and Crick, G. C., On some new and imperfectly-defined species of Jurassic, Cretaceous, and Tertiary nautili contained in the British Museum (Natural History): *Annals Mag. Nat. Hist.*, ser. 6, vol. 5, pp. 407–408, text fig. 8, 1890.

[65] Ravn, J. P. J., Molluskerne i Danmarks Kridtaflejringer; II, Scaphopoder, Gastropoder og Cephalopoder: *Mus. Min. et Géol. l'Univ. Copenhague*, Comm. Pal., no. 2, pp. 242–246, pl. 4, figs. 3–4; pl. 5, fig. 3, 1902.

[66] The specimen illustrated by Foord and Crick also came from Faxe, but it obviously represents only the adolescent portion of the conch, and since all representatives of this genus are more or less alike during their juvenile stages, specific comparisons with this specimen would be futile.

different authors. Harris states that "this species ranges from the highest to the lowest Midway," but we are inclined to believe that he allowed the species more latitude than we would. Gardner[67] has stated that *H. ulrichi* "does not . . . occur within the State of Texas," but the collections we are studying contain several typical representatives of this species from six miles north of Lockhart, in Caldwell County, Texas. All of the specimens in our collections that we are referring to this species came from the lower portion of the Midway of Texas and Alabama.

HERCOGLOSSA MCGLAMERYAE Miller and Thompson, n. sp.
Plate 38, figures 1, 2

The paleontological collections of the Alabama Museum of Natural History contain an essentially complete and well preserved internal mold of a moderately large nautiloid that clearly represents the genus *Hercoglossa* but is not referable to any described species. We propose to call it *Hercoglossa mcglameryae*, in honor of Miss Winnie McGlamery, paleontologist of the Museum.

Conch moderately large, subdiscoidal in shape, and nautiliconic in its mode of growth. The holotype, which represents a mature individual, attained a maximum diameter, measured from the adoral end of the venter across the umbilicus to the opposite side of the specimen, of at least 175 mm.; the diameter at right angles to this and across the umbilicus measures about 125 mm. The conch is very broadly rounded laterally, narrowly rounded ventrally, and deeply impressed dorsally. At the adoral end of the holotype, which apparently is not far removed from the aperture, the maximum height of the conch measures about 110 mm. and the maximum width (which is attained at the umbilical shoulders) measures about 85 mm. At the adapical end of the outer volution of the holotype the maximum height and width of the conch both measure about 40 mm. As is indicated by these figures the conch is expanded orad fairly rapidly.

The umbilicus is very small but unless an umbilical callus was developed a small portion of the inner volutions was probably exposed in the center of the umbilical depressions. The umbilical shoulders though low are almost subangular and are very distinct. The umbilical walls are essentially flat and they are inclined to the adjacent part of the lateral sides of the conch at an angle of about 135 degrees. The maximum diameter attained by the umbilicus of the holotype measures about 30 mm., which represents only about one-sixth the maximum diameter of the specimen.

The living chamber of the holotype is not complete, but it was at least one-third of a volution in ex-

[67] *Op. cit.*

EXPLANATION OF PLATE 38

FIGS. 1, 2—*Hercoglossa mcglameryae* Miller and Thompson, n. sp. Ventral and lateral views of the holotype, from the Midway of Lowndes County, Alabama, ×⅔.

1

2

Miller and Thompson, Eocene nautiloids

tent. The umbilical regions in the adoral portion of the conch apparently were not flared as were those of *Hercoglossa ulrichi*.

The internal mold at least is smooth and is entirely devoid of markings other than the sutures. Each suture forms a broad, deep, rounded ventral saddle; a broad, deep, asymmetrical, rounded lateral lobe, which centers near the mid-height of the conch; and a narrower, deep, narrowly rounded lateral saddle, which is essentially symmetrical and which centers only slightly ventrad of the umbilical shoulder (see text figure 2). The internal sutures are not visible on the holotype and only known representative of this species but doubtlessly they are very similar to those of *Hercoglossa orbiculata*, described above. The trace of the suture across the umbilical wall is essentially straight.

The camerae are moderate in length, but the distance between adjacent sutures varies on the different portions of the conch. In general the length of the camerae gradually increases adorally as the conch increases in size, but the two adoral camerae of the phragmacone of the holotype are distinctly shorter than the preceding ones, which indicates that the specimen represents a mature individual. Along the venter the distance between successive sutures is normally equal to about two-fifths the maximum height of the conch. Along the ventral flanks of the lateral lobes the distance between adjacent sutures is only very slightly less than the distance between the centers of these lobes, but along the dorsal flanks of the lateral lobes the distance between adjacent sutures is very strongly decreased. Unfortunately, nothing is known in regard to the siphuncle of this species, but presumably it is not greatly different from that of *Hercoglossa ulrichi*, described above.

Remarks.—This species seems to be more nearly similar to *Hercoglossa ulrichi* (White) and *H. tuomeyi* Clark and Martin s. s. than to any other described species. Its conch is somewhat more strongly compressed than is that of *H. ulrichi* and its sutures are not precisely similar; in *H. mcglameryae* the lateral saddles of the sutures are much narrower than are those of *H. ulrichi* and the lateral lobes are correspondingly wider, more broadly rounded, and more strongly asymmetrical, and the ventral saddles are more narrowly rounded. Other differences between these two species are listed in the discussion of *H. ulrichi*. *H. tuomeyi* s. s. is a much larger form and the lateral saddles of its sutures are wider and more broadly rounded.

The specimen from the Midway equivalent in Trinidad that Harris (Johns Hopkins Univ. Studies in Geol., no. 7, pl. 18, fig. 14, 1926) figured and referred to *Hercoglossa ulrichi* appears to be related to *H. mcglameryae*, but the only published illustration of that specimen is not very satisfactory and is not accompanied by a description.

Occurrence.—The holotype and only known representative of this species came from the Midway of Lowndes

County, Alabama; its lithology indicates that it came from the so-called "Nautilus Rock" of the Clayton formation (basal Midway).

Repository.—Alabama Museum of Natural History, University, Alabama.

ADDENDUM

Since this manuscript was written, it has come to our attention that K. Martin (Dienst v. d. Mijnb. in Ned.-Indië, Meded. no. 20, pp. 1–2, 1932) recently proposed the name *Javanoceras* for a form from the Eocene of Java that he described as *Nautilus* (*J.*) *intuscatenatus*. This species apparently should be referred to *Cimomia*, and *Javanoceras* should therefore be suppressed as a synonym of *Cimomia*.

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SOME OSTRACODES FROM THE BELL SHALE, MIDDLE DEVONIAN, OF MICHIGAN

HERBERTA L. VAN PELT

ABSTRACT

The following paper consists of detailed descriptions of fifteen species of Ostracoda from the Bell shale, a Middle Devonian formation of Michigan. Of these species, only two can be definitely referred to previously described forms. Of the ten genera, two are new. The families and genera are Primitiidae represented by *Primitiopsis;* Beyrichiidae represented by *Hollina;* Kloedenellidae represented by *Amphissites* and *Graphiodactylus;* Thlipsuridae represented by *Octonaria, Ropolonellus* and *Hyphasmaphora;* Entomidae represented by *Entomis;* and Cytherellidae represented by *Cytherella.* The new genera are *Ropolonellus* and *Hyphasmaphora.*

INTRODUCTION

The original material used in this paper was collected from a shale pocket in the Dundee limestone in Calcite quarry, Rogers City, Presque Isle County, Michigan. Additional material was obtained from a quarry in Alpena, from Rockport quarry and from a road cut near the town of Bell. There are slight differences in the material from these three places although the aspect of the fauna is the same. Most of the species found in the Rogers City sample are common to the others with the exception of *Hollina devoniana* and *Ropolonellus papillatus.* The same forms *Octonaria quadricostata, O. percarinata, O. crescentiformis,* and *Primitiopsis unicornis* are most abundant in all localities. New species are found in the Alpena, Rockport and Bell localities, which may be due in part to the limited supply of Rogers City material. The Bell shale is the basal member of the Traverse group which rests disconformably on the underlying Dundee limestone. Throughout the Traverse are blue shales, so similar lithologically to the Bell as to defy differentiation except on paleontologic evidence.

On the whole, the general aspect of the Ostracoda fauna of the Bell shale is similar to that of the Devonian Bryozoa beds from the Falls of the Ohio, described by E. O. Ulrich in 1890.[1] Some species in one formation are similar in most respects, but not identical to species in the other. The differences, although usually small, are sufficient to denote distinct species. On the other hand, the general aspect of the Ostracoda fauna

[1] Ulrich, E. O., New and little known American Palaeozoic Ostracoda: *Cincinnati Soc. Nat. Hist., Jour.,* vol. 13, pp. 104–137, 173–211, 1890.

of the Haragan marl, Devonian of Oklahoma, described by Robert Roth[2] in 1929, is decidedly different from that of the Bell shale. The Haragan forms are bizarre in shape and surface sculpturing.

For convenience to the reader, the descriptions are divided into six parts. The shape is considered first, and then in order; the dimensions surface features, marginal features, internal features and discussion.

Family PRIMITIIDAE Ulrich and Bassler
Genus PRIMITIOPSIS Jones

PRIMITIOPSIS UNICORNIS Van Pelt, n. sp.
Plate 39, figures 23–28

Elongate-ovate, tumid. Maximum length 1.12–1.48 mm., measured midway between the venter and the dorsum. Maximum height 0.64–0.76 mm., measured midway between the ends. Maximum breadth is measured through the posterior quarter.

The surface is rough with indistinct reticulations. At the center of the valve in most specimens is a small subcircular smooth area, which is more distinct on the right valve. It is probably a muscle scar. The tubercle is situated in the posterior quarter just ventrad of the line of maximum length. The tubercle in most cases is missing from the left valve.

Dorsal margin convex with a long gentle slope to the anterior end. The anterior cardinal angle is a little more acute than the rounded posterior angle. The anterior end is a little narrower than the posterior. The ends are subequally rounded. Ventral margin is nearly straight, but a little concave at the mid-length on the right valve and slightly convex in the corresponding part of the left valve.

Ventral margin of the right valve appears concave at the mid-length and convex where it is thickened in the corresponding place on the left valve. There is a ridge along the free margin of the left valve against which the edge of the right valve fits. The left valve completely overlaps the right. The hinge is along the posterior dorsal slope. On the right valve is a hinge groove into which fits the edge of the left. The ratio of the length of the hinge to the maximum length of the carapace is about 2 to 5.

Discussion.—This form is not congeneric with *P. punctulifera* (Hall).[3] Jones' figure shows a specimen with a long straight dorsum and entirely different hinge. In 1890, Jones[4] referred *Leperditia punctulifera* Hall to the genus *Primitiopsis. L. punctulifera* Hall has a short hinge line on the posterior slope of a convex dorsum. The specimen from the Bell shale agrees with this feature. Jones[5] does not mention whether the tubercles are equally developed on both valves and only left ones are illustrated. In the Bell specimens the tubercle is distinct on the right valve and either missing or very faint on the left valve. A specimen from the

[2] Roth, Robert, Some ostracodes from the Haragan marl, Devonian, of Oklahoma: *Jour. Paleontology*, vol. 3, pp. 327–372, 1929.

[3] Jones, T. R., *Geol. Soc. Canada, Contr. to Canadian Micropaleontology*, pt. 3, p. 95, pl. 11, Fig. 10, 11 *a, b*, 1891.

[4] Jones, T. R.: *Geol. Soc. London, Quart. Jour.* vol. 46, p. 9, 1890.

[5] *Idem.*

Bassler collection in Walker Museum at the University of Chicago, which is referred to *Primitiopsis* ? *punctulifera* has two posterior tubercles and instead of a median one, there is a smooth unornamented area in the center of the valve. There is, however, an anterior tubercle which in one specimen is apparently dorsad and in another ventrad. Only right valves are present in the collection so it is impossible to tell whether the tubercles are well developed on the left valve. In a third specimen in the same collection, the left valve has no tubercles, but has the central spot, and the right valve has the central spot and a faint suggestion of a single posterior ventrad tubercle. Hall's[6] original description of the species mentions only one tubercle at one extremity, not stating which one, and a distinct ventral overlap, not stating which valve is the larger. If it were sufficiently like a *Leperditia* to be classed there, the right valve probably overlaps the left. The specimen is not figured and Jones in reclassifying it did not mention the overlap.

It seems doubtful, if the variation in numbers and location of the tubercles is consistent in a single species. The variation in shape, length of the hinge line, and manner of hingement seems inconsistent within a single genus. It, therefore, seems that either the figure and description in the Canadian Micropaleontology are misleading or that the specimen is not a *Primitiopsis punctulifera;* that the specimen described in the Quarterly Journal of Geological Society is not conspecific with Hall's original description; that the specimens of *Primitiopsis*? *punctulifera* in the Bassler collection in Walker Museum at the University of Chicago are not conspecific with any of the above mentioned; that the three specimens in the Bassler suite may not even belong to the same species; that the Bell shale specimens are slightly different from all of the above mentioned but are most closely related to the Erian (Hamilton) specimen from Thedford, Ontario, of the Bassler suite and to the original one described by Hall. Further work may prove that variations in number and position of the tubercles are individual differences within the species, but at present, since it is possible to distinguish between characteristics of the groups the Bell shale specimens are grouped in a new species. It is also doubtful whether these specimens actually belong to the genus *Primitiopsis* as described by Jones because of the lack of internal segmentation which is mentioned in the generic description.

Bell shale, Middle Devonian, Michigan.

[6] Hall, James, *13th Ann. Rep't Reg. U. N. Y.*, p. 92, 1860.

Family BEYRICHIIDAE Jones

Genus HOLLINA Ulrich and Bassler

HOLLINA DEVONIANA Van Pelt, n. sp.
Plate 39, figures 33–36

Arc-shaped, elongate, produced and tapering anteriorly. Valves with a marginal frill which originates at the posterior end, ventrad one-fourth distance from the dorsum to the venter, and extends a little anterior of

the mid-length of the venter. Maximum length 1.12–1.44 mm., measured on a line with the dorsal extremity of the frill. Maximum height, including the frill, 0.64–0.72 mm., measured perpendicular to the hinge line, from the posterior dorsal node to the ventral edge of the frill; excluding the frill, the maximum height is measured at right angles to the hinge line through the dorsal part of the anterior node.

There is a prominent dorsal node midway between the median sulcus and the posterior extremity. Ventrad of this node is a second, less prominent, bifurcate node which is connected with a large swollen anterior node by a U-shaped ventral ridge. The anterior part of the bifurcate, posterior node is the more prominent. The surface of the nodes (with the exception of the post-dorsal one) and the ridge are covered with small tubercles. There is a slight suggestion of a repressed anterior node in the center of the anterior area. Along the venter, anterior to the termination of the frill and at the anterior tip there are small tubercles.

Dorsal margin straight. The posterior cardinal angle is obtuse; the anterior angle is about ninety degrees. Ventral margin is convex, sloping rapidly in a dorsal direction anteriorly.

Articulation is relatively simple. On the left valve, there is a ridge and groove along the hinge line, into which the right valve probably fits. The ratio of the length of the hinge to the maximum length of the carapace is about 7 to 8. Overlap can not be determined, because of lack of material. Along the inner ventral margin of the right valve there is a groove which probably accommodates and overlaps the rabbetted edge of the left valve. From the anterior, the frill is seen to be wider at the posterior and to slope away gently on the ventral margin.

Discussion.—This species is similar to *H. granifera* (Ulrich),[7] from the St. Louis limestone, but differs from it in having the posterior node bifurcate and also in having a posterior dorsal node. The frill is not crenulated nor concave. The only Devonian species it resembles is *H. antespinosa* (Ulrich)[8] from the Devonian Bryozoa beds at the Falls of the Ohio. They are easily distinguished because in *H. devoniana* the anterior node is missing, the frill is not geniculated or channeled and there is one posterior node and a bifurcate central posterior node, instead of one in three steps. The anterior end is also less rounded, more produced and narrower.

Bell shale, Middle Devonian Michigan.

Family KLOEDENELLIDAE Ulrich and Bassler

Genus DIZYGOPLEURA Ulrich and Bassler

DIZYGOPLEURA TRISINUATA Van Pelt, n. sp.
Plate 39, figures 61, 62

Elongate subovate. Maximum length 1.5 mm., measured parallel the dorsal margin, midway between

[7] Ulrich, E. O., *Cincinnati Soc. Nat. Hist., Jour.*, vol. 13, p. 205, 1890–92.
[8] *Idem*, p. 187.

the venter and dorsum. Height 0.5 mm., nearly uniform throughout the entire length. Maximum breadth is measured through the anterior lobe.

Anterior and posterior sulci nearly parallel each other; the former does not extend to the dorsal margin as does the latter. Posterior sulcus curves a little anteriorly at the ventral edge. They both extend three quarters of the way to the venter. The median sulcus curves backward and extends half way from dorsum to venter. The surface is divided into four subequal parts by the sulci. The two medial nodes are joined ventrally. The summit of the anterior node is a curved ridge. From the top of the posterior lobe, the slope is gentle to the edge. From the top of the anterior lobe, the slope is more abrupt. There is an unornamented border around the free margin.

Dorsal margin nearly straight, with anterior cardinal angle short and very obtuse and the posterior cardinal angle very long and not quite as obtuse. The anterior margin is rounded and produced, the posterior margin is rounded, but more rectangular. Ventral margin is nearly straight, but slightly concave near the mid-length.

There is a groove along the hinge of the left valve into which the edge of the right probably fits. The right valve *overlaps* the left valve on the venter and ends and the left valve overlaps the right on the dorsum. The ratio of the length of the hinge to the maximum length of the carapace is about 3 to 5. The lobation is noticeable on the interior of the valves

Discussion.—In surface sculpturing, this species is similar to *Kloedenella halli* (Jones), a Silurian form.[9] The Devonian species, however, is more elongate and the ratio of its length to its height is 3 to 1 instead of a little less than 2 to 1. *D. trisinuata* belongs to group 4. Its surface markings are similar to those of *D. swartzi* Ulrich and Bassler,[10] but the carapace of *D. trisinuata* is more produced anteriorly. It is also similar to another Silurian form, *D. stosei* Ulrich and Bassler,[11] but *D. trisinuata* has no anterior spine and the anterior is more produced. It is easily distinguished from all other species.

Bell shale, Middle Devonian, Michigan.

Family KIRKBYIDAE Ulrich and Bassler

Genus AMPHISSITES Girty[12]

AMPHISSITES DIADEMATUS Van Pelt, n. sp.
Plate 39, figures 8–15

Subovate with subrectangular raised area enclosed by a false keel. Maximum length of carapace 0.9 mm., measured parallel the hinge line midway between the venter and dorsum; maximum length of raised area is measured midway between the venter and the medial line. Maximum

[9] Jones, T. R., *Geol. Soc. London, Quart. Jour.*, vol. 46, p. 15, 1890.

[10] Ulrich E. O., and Bassler, R .S., *Maryland Geol. Survey, Silurian Vol.*, p. 693, 1922.

[11] *Idem*, p. 695.

[12] Girty, G. H., *New York Acad. Sci., Annals*, vol. 20, pt. 2, p. 235, 1910. Roth, Robt., *Wagner Free Inst. Sci., Publ.* vol. 1, pp. 32–34, 1929. Knight, J. Brookes, *Jour. Paleontology*, vol. 2, pp. 248–249, 1928. Geis, H. L., *Jour. Paleontology*, vol. 6, pp. 153–155, 1932.

height 0.6 mm., measured at right angles to the hinge line, a little posterior of the central pit. Maximum breadth, excluding the marginal shoulders, is measured perpendicular to the surface of the valve a little posterior of the central pit.

A false keel on each valve forms the edge of the elevated area, roughly parallels the free margins and meets the hinge line at the cardinal angles. Although rather indistinct, there appear to be two rows of reticulations on the false keel. Inner transverse

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EXPLANATION OF PLATE 39

FIGS. 1, 2—*Cytherella quaesita* Roth. 1, Complete specimen showing right valve, ×35. 2, Complete specimen showing left valve, ×20.

3–7—*Hyphasmaphora textiligera* n. sp. 3, Right valve of topotype, ×25. 4, Right valve of topotype, ×42. 5, Right valve of genotype, ×25. 6, Right valve of topotype, ×25. 7, Right valve of topotype, ×25.

8–15—*Amphissites diadematus* n. sp. 8, Right valve of topotype, ×25. 9, Interior of right valve of topotype, ×25. 10, Interior of left valve of topotype, ×25. 11, Left valve of holotype showing overlapping right valve, ×20. 12, Right valve of topotype, ×25. 13, Left valve of topotype, ×25. 14, Right valve of holotype, ×20. 15, Ventral view of holotype with left valve to the right, ×20.

16—*Octonaria singularis* n. sp. 1, Holotype; dorsal view with anterior down, ×25.

18–20—*Amphissites subquadratus* (Ulrich). 18, Single right valve of cotype, ×20. 19, Single right valve of cotype, ×25. 20, Interior of right valve of topotype, ×25.

21, 22—*Entomis rugatulus* n. sp. 21, Left valve of holotype, ×20. 22, Left valve of topotype, ×25.

23–28—*Primitiopsis unicornis* n. sp. 23, Right valve of topotype showing overlap of left valve, ×25. 24, Right valve of cotype, ×25. 25, Left valve of cotype, ×25. 26, Interior of the right valve of a cotype, ×25. 27, Interior of a left valve of a cotype, ×25. 28, Ventral view of a cotype showing left valve overlapping right valve, ×20.

29, 30—*Ropolonellus papillatus* n. sp., n. gen. 29, Complete specimen with left valve on top; genotype, ×25. 30, Interior of left valve of allotype, ×25.

31, 32—*Graphiodactylus catenulatus* n. sp. 31, Complete specimen of cotype with left valve on top, ×25. 32, Left valve of cotype showing overlapping right, ×25.

33–36—*Hollina devoniana* n. sp. 33, Right valve of cotype, ×25. 34, Left valve of cotype, ×25. 35, Interior of left valve of cotype, showing internal lobation, ×25. 36, Internal of left valve of cotype, ×20.

37–40—*Amphissites bellipunctus* n. sp. 37, Right valve of cotype, ×25. 38, Left valve of cotype showing surface reticulations, ×25. 39, Left valve of cotype, ×25 40, Interior of left valve of cotype, ×25.

41–51—*Octonaria quadricostata* n. sp. 41–44, 46, Right valves of paratypes showing variation from holotype, ×25. 45, Right valve of holotype, ×25. 47, Interior of right valve of allotype, ×25. 48, Left valve of paratype, ×25. 49, Interior of left valve of allotype, ×25. 50, Left valve of allotype showing right valve overlapping left, ×20. 51, Left valve of paratype showing right valve overlapping left, ×20.

52–54—*Octonaria percarinata* n. sp. 52, Left valve of cotype, ×25. 53, Right valve of topotype, ×25. 54, Interior of right valve of topotype, ×25.

55–60—*Octonaria crescentiformis* n. sp. 55, Right valve of allotype, ×25. 56, Interior of right valve of allotype, ×25. 57, Left valve of paratype showing overlap of right, ×20. 58, Left valve of holotype showing overlap of right, ×25. 59, Left valve of topotype, ×25. 60, Left valve of topotype, ×25.

61, 62—*Dizygopleura trisinuata* n. sp. 61, Left valve of holotype, ×20. 62, Right valve of topotype, ×25.

Van Pelt, Devonian ostracodes

false keels, or elongate nodes, form posterior and anterior shoulders, the former being the higher and the more prominent. These shoulders extend a little above the hinge line and slope inward to the dorsal center. Paralleling the ventral margin, there is a groove at the dorsal edge of the false keel on each valve, which deepens posteriorly and slopes up to the general surface anteriorly. Dorsad of the groove is a ridge paralleling the ventral margin. This ridge is more prominent on the right valve.

The surface ornamentation is regular. There is no central node, although there is a swollen area posterior of the central pit. The surface is covered with polygonal reticulations which are nearly hexagonal. The central pit is oval, and its length is about three times that of a reticulation. The long axis of the pit is perpendicular to the hinge line.

Dorsal margin straight with posterior cardinal angle more acute than the anterior angle. Laterally the dorsal margin is bounded by a narrow, inclined, unornamented area, extending the length of the hinge on the left valve. It is less distinct on the right valve. Ventral margin nearly straight.

There is a groove terminating in a small socket at each end, along the hinge line of the right valve, probably for the accommodation of the hinge and teeth of the left valve. The ratio of the length of the hinge to the maximum length of the carapace is about 2 to 3. The right valve overlaps the left. Along the free margin of the right valve is a flange which is grooved on the inner side to accommodate the flange of the left valve.

Discussion.—The inner false keel, groove and ridge are less prominent on some specimens than on the type. This species is very distinctive, because of the prominence of the keels and the convexity of the carapace. It is similar to one specimen of *A. subquadratus* (Ulrich)[13] in the suite of metatypes from the Devonian Bryozoa beds from the Falls of the Ohio in the Bassler collection in the Walker Museum at the University of Chicago, but may be distinguished from that species by its smaller reticulations and its inner false keels or nodes.

Bell shale, Middle Devonian, Michigan.

AMPHISSITES SUBQUADRATUS (Ulrich)

Plate 39, figures 18–20

Amphissites subquadratus Ulrich, *1890*, Cincinnati Soc. Nat. Hist., Jour., vol. 13, p. 192.

Subrectangular. Maximum length 0.92 mm., measured parallel to the hinge line, midway or slightly ventrad of midway between the venter and dorsum. Maximum height 0.6 mm. measured at right angles to the hinge line, a little posterior of midway between the ends. Maximum breadth, excluding the marginal shoulders, is measured perpendicular to the surface of the valves, posterior of the central pit.

A low and not very prominent false keel on each valve parallels the free margin. The false keel meets the

[13] Ulrich, E. O., *Cincinnati Soc. Nat. Hist., Jour.*, vol. 13, p. 192, 1890.

hinge line at the cardinal angles forming low shoulders; the posterior shoulder being the more prominent.

The surface is regularly ornamented by nearly hexagonal reticulations. The oval pit is subcentrally situated and in length is about three times that of a single reticulation. The pit is oriented with its long axis oblique to the hinge line, with the dorsal end directed posteriorly.

Dorsal margin straight with subequal cardinal angles, the anterior angle being slightly more obtuse than the posterior angle. The dorsal margin is bounded by narrow, inclined unornamented areas which extend the length of the hinge line. Ventral margin nearly straight, although very slightly concave near mid-length.

Articulation is the same as in other species of this genus. Teeth, under the cardinal angles of the left valve probably fit into corresponding sockets on the right valve. A groove along the hinge of the right valve probably accommodates the edge of the left valve. The ratio of the length of the hinge line to the maximum length of the carapace is about 3 to 4. Overlap can only be inferred from the indistinct grooving of the right valve, along the inner side of the venter, for the probable reception of the edge of the left valve.

Discussion.—This species differs from *A. diadematus* in shape and surface sculpturing. In the latter, the posterior cardinal angle is more obtuse and more rounded; the ratio of the height to the length is 2 to 3 instead of 1 to 2; the false keels are more prominent and form an elevated or crown-like area, and the central pit is more distinct and is oriented perpendicular to the hinge line.

It is similar to another Devonian form, *A. parallelus* (Ulrich),[14] in shape. The keel is nearer the margin and less pronounced and the pit is larger than in *A. parallelus*. It is less convex than the Chester form, *A. oblongus* (Jones).[15] It is also similar to one specimen of *A. subquadratus* (Ulrich) from the Devonian Bryozoa beds at the Falls of the Ohio in the suite of metatypes in the Bassler collection in the Walker Museum at the University of Chicago. The specimen referred to does not appear similar to the other specimens of the same species in the collection. It is, perhaps, a separate species.

Bell shale, Middle Devonian, Michigan.

AMPHISSITES BELLIPUNCTUS Van Pelt, n. sp.
Plate 39, figures 37–40

Subquadrate, subovate. Maximum length 0.48–0.58 mm., measured parallel the hinge line midway between the dorsum and venter. Maximum height 0.28 mm., measured midway between the ends. Maximum breadth is measured (excluding the posterior end of the ventral ridge) through the anterio-ventral quarter.

A dorsal suture, situated a little anterior of midway between the extremities of the valve, extends from a little dorsad of central where it appears as a true Kirkyian pit, to the

[14] *Idem*, p. 192, pl. 15, figs. 2 *a*, *b*.
[15] Jones, T. R.: *Annals and Mag. Nat. Hist.*, (5), vol. 15, p. 181, 1885.

hinge line. The ventral ridge-like swelling ends in a prominent ventral node. The dorsal and ventral edges of the swelling are abrupt. The free margin is composed of a vertical band or false keel which joins the hinge line at the cardinal angles. No nodes or shoulders are formed. The surface is covered with subcircular reticulations. The surface of the ventral ridge is also reticulated and the reticulations form three longitudinal costae, the most dorsad being the most prominent. Dorsal margin is straight with the anterior cardinal angle somewhat obtuse and the posterior angle slightly acute. The ends are subequally rounded. Ventral margin is uniformly convex. The dorsal margin is bounded by an inclined, unornamented area, which extends the length of the hinge.

Articulation can not be determined because of poor preservation. The length of the hinge line is almost equal to the maximum length of the carapace. The ventral margin of the right valve appears to be rabbetted to receive the edge of the left valve.

Discussion.—The median dorsal sulcus and ventral ridge are characteristic of *Beyrichiella* and *Jonesina*, but the lobation of typical Beyrichiidae is missing. The specimen is similar to *Primitia eichwaldi* Jones and Kirkby[16] from the Carboniferous of Russia, and also to the Upper Silurian form *P. variolata* Jones and Kirkby,[17] but the shape of the specimen under consideration is more typical of the Kirkbyidae. *A. bellipunctus* is rather similar to *Kirkbya tumida* Roth.[18] The ends of *A. bellipunctus* are more nearly equal, there is only one false keel, the longitudinal ridge is more ventrad, there are longitudinal costae on the ridge, and the pit is connected dorsally with a sulcus. The unornamented area parallels the hinge for its entire length.

Bell shale, Middle Devonian, Michigan.

Family KIRKBYIDAE

Genus GRAPHIODACTYLUS Roth

GRAPHIODACTYLUS CATENULATUS Van Pelt, n. sp.

Plate 39, figures 31, 32

Subovate, tumid. Maximum length 0.52 mm., measured a little ventrad of midway between the venter and dorsum. Maximum height 0.32 mm., measured a little posterior of midway between the extremities. Maximum breadth is measured through the anterior quarter.

Near the anterior end of the valve is an obscure transverse ridge terminating dorsally and ventrally with small faint nodes or tubercles. The slope to the anterior edge is abrupt, but posteriorly it is very gradual. There is a small circular, central pit. The surface is covered with rows of pits, which appear chain-like. They diverge from ventrad of the center of the posterior half of the valve, the angle of divergence being greater on the dorsal than on the ventral half. There is a frill on the posterior and

[16] Jones, T. R., and Kirkby, J. W., *Annals and Mag. Nat. Hist.*, (4), vol. 15, p. 55, 1875.

[17] Jones, T. R., and Kirkby, J. W., *Annals and Mag. Nat. Hist.*, (3), vol. 16, p. 418, 1865.

[18] Roth, Robert, *Wagner Free Inst. Sci., Pub.*, vol. 1, p. 27, 1929.

ventral margins. The development of the frill varies in different individuals.

Dorsal margin is convex with the posterior cardinal angle long and very obtuse and the anterior angle short and only slightly obtuse. Ventral margin is convex. The anterior end is nearly equally rounded dorsally and ventrally. The greatest convexity of the posterior margin is near the venter.

There is a groove along the hinge of the left valve, other features are obscure. The right valve overlaps the left all around, except at the posterioventral corner, where the frill makes it appear as if the left valve is larger. The ratio of the length of the hinge line to the maximum length of the carapace is about 1 to 2.

Discussion.—This species differs from the genotype in having no papillae or horns and having a definite flattened area in front of the ridge through which is measured the maximum breadth of the carapace. The central pit is also present in the new species. The riblets and shape are similar to those of the genotype. The frill varies in development. No transverse depression is found. Dentition and overlap are indefinitely known as the only single-valved specimens in the collection are poorly preserved.

Bell shale, Middle Devonian Michigan.

Family THLIPSURIDAE Jones
Genus OCTONARIA Jones
OCTONARIA CRESCENTIFORMIS Van Pelt, n. sp.
Plate 39, figures 55–60

Subovate. Maximum length 0.68 mm., measured parallel the venter through the center of the ends. Maximum height 0.4 mm., measured through the posterior third. Maximum breadth is measured through the anterior end of the plateau.

A low plateau roughly parallels the margins. The surface outside of the plateau appears smooth. An indistinct border is seen at each end.

Right valve: There is a dorsal crescentic groove, which swings down to the center of the valve anteriorly. Just ventrad of the groove and slightly dorsad of the line of maximum length is another small groove composed of two indistinct parts. Anterior of the crescentic groove there is an abrupt drop to the flat area of the valve. The anterior half of the crescentic groove is divided into three indistinct parts. In some specimens, there is another curved groove ventrad of the line of maximum length and nearly paralleling the venter. The surface is smooth.

Left valve: The dorsal crescentiform groove turns downward anteriorly and then turns backward forming a hook which is divided ventrally into two pits. The central groove is also present.

The ventral margin is nearly straight, but slightly convex. The ends and cardinal angles are subequal. The dorsal margin is convex with the anterior slope slightly longer than the posterior slope.

The hingement is simple. The ends are thickened a little beyond the meeting of the valves. The ratio of the length of the hinge to the maximum length of the valve is about 3 to

5. The right valve overlaps the left on all margins. The overlap is greatest along the venter and the ends.

Discussion.—The orientation is difficult because the hinge line is so indistinct. It is oriented here in accordance with the general orientation of the Thlipsuridae. It is rather similar to *Thlipsura* in shape, but it can be definitely referred to *Octonaria*, because of the plateau. This species is distinguished from all others of this genus by the dorsal crescentic, and ventral longitudinal surface ornamentation. There is little doubt of its relationship to the Thlipsuridae, but it differs from other Devonian *Octonaria* from the Bell shale in that the overlap is not as pronounced, the surface sculpturing is less regular and the venter is straighter than in the others. It is, however, similar in shape to *Octonaria* of other formations.

Middle Devonian, Michigan.

OCTONARIA PERCARINATA Van Pelt, n. sp.
Plate 39, figures 52–54

Subrhomboidal. Maximum length 0.8 mm., measured midway between the venter and dorsum. Maximum height 0.48 mm., measured through the posterior end of the dorsum. Maximum breadth is measured through the interior dorsal part of the ridges.

The surface of the centrally tumid portion, or plateau on the right valve is covered with four crinkled, irregular, longitudinal ridges, which appear as two parallel loops, one within the other and open at the anterior end. Outside these wrinkles is a groove which is indistinct at the anterior. The margins, with the exception of the anterior, bend upward. The markings on the left valve are slightly different. An horizontally flattened figure eight, paralleling the dorsum and enclosing two parallel longitudinal grooves, is formed by the dorsad ridges. There is a transverse groove a little posterior of the middle, running from the dorsum to the ventral ridge. The ventral ridge turns upward and posteriorly parallels the posterior end. A longitudinal groove separates the ventral ridge from the lower part of the dorsal ridges, except anteriorly where they are joined. The posterior end of the dorsad ridges is joined by an inconspicuous transverse ridge. There are several papillae on the anterior margin.

Dorsum is straight with the posterior cardinal, angle slightly obtuse and long. The posterior end is wide and subequally rounded. It is almost angular where it joins the venter. The anterior cardinal angle is slightly more obtuse than the posterior, and short. The anterior end is narrow and subequally rounded. Venter appears straight from the exterior, but from the interior the posterior part of the venter appears convex and straightening out toward the mid-length.

The hinge is composed of a groove along the dorsum of the right valve and a similarly located ridge on the left valve. From the interior a narrow flange is seen to extend beyond the contact edges of the ends of the carapace. On the anterior end of the flange, there are from two to six small papillae. The edge of the valves

is marked by a narrow ridge. The right valve completely overlaps the left. The hinge extends the entire length of the dorsum, but only about four-fifths of the maximum length of the carapace.

Discussion.—This species resembles *Octonaria stigmata-loculosa* Ulrich[19] from the Devonian Bryozoa beds at the Falls of the Ohio, in shape, but not in surface markings. There is no species with which *O. percarinata* can be confused because of the lack of cross-hatching in the surface sculpture, the arrangement of the ridges and the minute papillae on the anterior end. There is some doubt as to whether the two species are congeneric with the more typically bean-shaped *Octonaria*. *Strepula plantaris* Jones[20] from the Devonian is much more closely allied in shape and surface marking to these above than to other species of the genus to which it is referred. Further work may show that *O. percarinata* and *S. plantaris* may be grouped together in a new genus under the Thlipsuridae.

Bell shale, Middle Devonian, Michigan.

OCTONARIA QUADRICOSTATA Van Pelt, n. sp.
Plate 39, figures 41–51

Subrhomboidal, tumid. Maximum length 0.72 mm., measured parallel the venter midway between the venter and dorsum. Maximum height 0.48 mm., measured through the posterior third. Maximum breadth is measured through the anterior edge of the plateau.

The surface of the right valve bears a plateau that parallels the dorsum and roughly parallels the free margin. It is situated away from the dorsum and ends, but close to and almost overhanging the venter, especially at the anterior. The bounding ridges of the plateau are abruptly elevated above the surface anteriorly and dorsally, and grade into the surface level at the posterior and venter. The plateau is smoothly rounded with no angles. It has two longitudinal ridges parallel to the bounding ridges and connected with them anteriorly. The ridges are separated by grooves and connected by alternating cross bars. The longitudinal ridges join a wide transverse ridge, which is situated a little posterior of the middle of the plateau, and which extends from the dorsad inner ridge to the venter. The transverse ridge broadens where the ventrad inner ridge joins it. Posterior of the transverse ridge, the cross-hatching is irregular. Between the plateau and the dorsum, the surface has one row of reticulations. The produced anterior end is covered with indistinct cross-hatchings. The posterior and ventral portions are smooth. There is an unornamented border on the dorsum and posterior.

The left valve has no definite plateau but is carved to give the effect of a bounding ridge, and a central longitudinal ridge separated by two longitudinal grooves. The grooves are crossed by small transverse ridges. A little posterior of cen-

[19] Ulrich, E. O., *Cincinnati Soc. Nat. Hist., Jour.*, vol. 13, p. 194, 1890.
[20] Jones, T. R., *Geol. Soc. London, Quart. Jour.*, vol. 46, p. 540, 1890.

tral is a broad transverse ridge extending across the valve. The posterior part is irregularly marked, but has one definite longitudinal ridge in the center. Dorsad of the transverse ridge is a pit.

The dorsum of the right valve is straight, with the posterior cardinal angle obtuse and long. The greatest convexity of the broad posterior end is near the ventral edge. The ends are unequally rounded. The anterior cardinal angle is more obtuse than the posterior one, and rounded. The anterior end is narrow, produced and evenly convex. Venter is slightly convex and slants obliquely upward to connect the broad posterior with the narrow anterior. The left valve is noticeably bean-shaped. The dorsum is convex with a long convex posterior slope. The anterior end is low and evenly rounded. The posterior end is high with the greatest convexity near the venter. The venter is concave in the middle and extends obliquely upward to connect the short anterior and long posterior ends.

Along the posterior cardinal angle there appears to be a rabbetted ridge on the right valve to fit into the pitted groove on the left. Venter is thickened into a flange at the middle, to overlap the concave part of the venter of the left valve. There is a groove and ridge on the free margin of the right valve, to accommodate the smaller left valve. F.M. Swartz[21] says of *Octonaria*, "hingement and overlap not always well understood, but there appears to be a tendency for the left valve to overlap the right, particularly along the hinge." However in studying the Bell specimens, the overlap was found to be complete with the greatest overlap in the central part of the venter. In accordance with Ulrich's orientation, the right valve is the overlapping one.

Discussion.—This species has three ridges on the left valve and so can be distinguished from *O. singularis*, which has four. There is considerable variation in shape and tumidity in this species.

Orientation is difficult. In this paper, the valves are oriented with the hinge line parallel the top of the page, in accordance with the orientation of Ulrich. Jones, in the original description, orients them with the venter parallel the top of the page and the dorsum convex. This simple revolution through about ten degrees gives the outline a very different appearance. With the present orientation, the specimen looks subrhomboidal instead of subovate. The specimen which Ulrich has described and figured as *Octonaria ovata* appears to be merely the left valve of a species similar to those here described. As he does not describe the right valve of that species, or left valves of the other species found in that horizon, it is uncertain whether or not they are distinct species or merely different valves of the same species. Ulrich's specimen is incorrectly oriented in the earlier figure[22] but corrected later.[23] There is suffi-

[21] *Jour. Paleontology*, vol. 6, p. 52, 1932.

[22] *Jour. Cincinnati Soc. Natural History*, vol. 13, pl. 16, fig. 6, 1890.

[23] *Maryland Geol. Survey*, Silurian, p. 317, fig. 23, *2*, 1923.

cient difference between the right and left valves of individuals of *Octonaria* to appear as distinct species when single valves are found. It is only when complete specimens are studied that it is possible to believe that such widely different valves belong not only to the same species, but to the same specimen.

Bell shale, Middle Devonian, Michigan.

OCTONARIA SINGULARIS Van Pelt, n. sp.

Plate 39, figure 16

Subrhomboidal. Maximum length 0.7 mm., measured midway between the venter and dorsum. Maximum height 0.34 mm., measured through the posterior third. Maximum breadth is measured through the anterior end of the plateau.

The plateau of the right valve is abruptly raised anteriorly and at the dorsum, but slopes down to the general surface of the valve posteriorly and ventrally. Including the bounding ridge, there are four parallel, longitudinal, anterior ridges separated by deep grooves and joined by alternating transverse ridges. A little posterior of the center of the plateau is a wide transverse ridge joining the three most ventrad ridges. Posterior of this are three narrow radiating ridges, joined by cross-hatching. The surface outside of the plateau is smooth, except dorso-anteriorly where it is coarsely reticulated. The plateau is set back from the margin, except ventrally. The plateau gives the impression of being tilted, as it extends farther above the surface at the venter where it almosts overhangs the margin.

On the left valve the sculpturing is much the same as on the right, but the two most dorsad ridges and intermediate grooves are not distinct and thus give the appearance of only three ridges and two grooves. Actually, however, there are four ridges and three grooves. The wide transverse ridge is more nearly in the center of the valve than is the corresponding ridge on the right valve. Dorsad of the ridge is a pit. The posterior ridges are not distinct.

Dorsum of the right valve is nearly straight, although slightly convex, with the anterior cardinal angle slightly obtuse and the anterior end evenly rounded. The posterior cardinal angle is very obtuse and long, with the greatest convexity of the end near the ventral margin. The venter is nearly straight, but slopes obliquely between the wide posterior and narrow anterior ends.

Dorsal margin of the left valve is slightly convex with the posterior cardinal angle long and obtuse. The anterior cardinal angle is shorter. The ends are subequally rounded. Venter is convex at the mid-length and rounds off into the ends. The shape of the valve is bean-like. The right valve is considerably larger.

The hingement is indistinct. On the left valve the hinge appears to be a groove containing a series of indistinct pits. The ratio of the length of the hinge to the maximum length of the carapace is about 1 to 2. The right valve overlaps the left considerably except at the dorsal margin

where the overlap is slight. The edges of the left valve are thickened, except at the venter.

Discussion.—*O. singularis* is similar to *O. stigmata* Ulrich[24] from the Devonian Bryozoa beds at the Falls of the Ohio, except that the Bell specimen has four longitudinal ridges, instead of five, the anterior is more produced and the dorsal surface is crosshatched. The four longitudinal ridges on the left valve distinguish *O. singularis* from *O. quadricostata* whose left valve contains only three longitudinal ridges.

Bell shale, Middle Devonian, Michigan.

ROPOLONELLUS Van Pelt, n. gen.

Carapace subrhomboidal, oblique, tumid. Dorsum straight with the posterior cardinal angle long and obtuse, the anterior end meets the dorsum at ninety degrees. The posterior end is very wide, the anterior very narrow. The venter is straight and oblique at mid-length and convex where it rounds off into the ends. The surface is smooth. The central part of the valve is very convex. It is compressed just inside of the marginal ridges. The hinge is simple, with a ridge on the left valve. The hinge is about three-fifths the maximum length of the carapace. The right valve is larger, overlapping the left especially at the venter and anterior. Genotype *R. papillatus*.

ROPOLONELLUS PAPILLATUS Van Pelt, n. sp.

Plate 39, figures 29, 30

Subrhomboidal. Maximum length 0.52–0.6 mm., measured obliquely from the anterior dorsal to the posterior ventral. Maximum height 0.24 mm., measured through the posterior end of the dorsum. Maximum breadth is measured through the center of the valve.

The surface is smooth and very tumid in the center. It is constricted near the anterior and posterior margins, which are raised into prominent ridges. The posterior ridge is lacking from the dorsal third of the margin. The ridges are more prominent on the left valve. There are papillae on the ridges, four on the anterior one.

Dorsum straight with the anterior ridge extending above the hinge line. The posterior cardinal angle, is long and obtuse. The greatest convexity of the end is near the venter. The posterior end is very wide and the anterior end is very narrow. The venter is straight and oblique in the center and convex where it rounds off into the ends.

The hinge line is straight and about three-fifths the maximum length of the carapace. There is a ridge along the hinge of the left valve. The right valve overlaps the left at the venter and at the posterior margins.

Discussion.—This species is not similar to any figured form. Although it has marginal ridges like *Moorea* it has not the same shape. The shape associated it with the Thlipsuridae.

Bell shale, Middle Devonian, Michigan.

HYPHASMAPHORA Van Pelt, n. gen.

Carapace subovate, convex. Dor-

[24] Ulrich, E. O. *Cincinnati Soc. Nat. Hist., Jour.*, vol. 13, p. 193, 1890.

sal margin long and straight with the cardinal angles subequally obtuse. Ends rounded, the posterior wider and a little more blunt than the anterior. Venter convex with the greatest curvature near the posterior margin. A narrow frill occurs at the anterior and posterior ends. The hinge is represented on the right valve by a denticulate groove, and is nearly as long as the carapace itself. There is a large, shallow central pit and the reticulated area is bounded by a sloping unornamented area, which is widest at the posterior. Genotype *H. textiligera*.

HYPHASMAPHORA TEXTILIGERA Van Pelt, n. sp.

Plate 39, figures 3–7

Subovate, tumid. Maximum length 0.6 mm. measured parallel the dorsum midway between the venter and dorsum. Maximum height 0.3 mm., measured a little posterior of midway between the ends. Maximum breadth is measured through the middle of the posterior half.

The suboval central part is covered with irregular polygonal reticulations. At the very center of the valve is a large, shallow circular pit, anterior and posterior of which the surface is swollen. Outside of the webbed area is a smooth sloping border, the edge of which forms a tubercle at the dorso- and ventro-anterior part. The anterior part of the webbed area is more abruptly elevated from the surface level than is the posterior part. There is a small frill-like flange at the posterior and anterior ends.

From the interior, the posterior cardinal angle appears less obtuse than the anterior one. Details of hingement and overlap can not be determined, but the right valve appears to be rabbetted at the ends for the overlapping left valve. The hinge is about three-fourths of the maximum length.

Discussion.—There is no old genus into which this species fits. It has a reticulate surface ornament and a central pit, but it has not the marginal ridge of *Kirkbya* or *Amphissites* nor is the shape quite that of those two genera. On the other hand it is very close to the Primitiidae, but there is no sulcus. As here oriented the shape and plateau are similar to the Thlipsuridae and especially to *Octonaria*, because of which for the present it is grouped with the Thlipsuridae.

Bell shale, Middle Devonian, Michigan.

Family ENTOMIDAE Jones

Genus ENTOMIS Jones

ENTOMIS RUGATULUS Van Pelt, n. sp.

Plate 39, figures 21, 22

Subrhomboidal, subovate. Ends unequally rounded, the posterior produced dorsally. Maximum length 0.84–1.04 mm., measured dorsad of midway between the venter and dorsum. Maximum height 0.4–0.56 mm., measured through the valve, just posterior of the dorsal sulcus. Maximum breadth is measured a little posterior of the dorsal sulcus and a little ventrad of the line of maximum length.

There is a very prominent dorsal sulcus a little anterior of midway be-

tween the ends of the carapace. The sulcus narrows slightly dorsally. The surface of the valves is covered with prominent wrinkles which are nearly longitudinal. On the anterior half they are oblique, with the dorsal ends directed posteriorly. Near the posterior end, they roughly parallel the margin and converge in a point, near the line of maximum length, on the dorsal part of the area. Between the wrinkles are numerous small subcircular reticulations or pits. Around the free margin is an unornamented border or frill which extends beyond the edge of the valves at the ends.

Dorsal margin appears somewhat sinuate, because the convexity of the valve at the posterior extends above the hinge line. The dorsum is convex, except a little anterior of the dorsal sulcus where it is concave. The anterior cardinal angle is slightly obtuse; the posterior cardinal angle is more obtuse. The anterior end is smoothly rounded; the greatest convexity of the posterior end is near the dorsum. Ventral margin is nearly straight.

Details of articulation are obscure, but there appears to be a projection along the straight hinge line of the left valve which probably fits into a corresponding groove on the right valve. The ratio of the length of the hinge line to the maximum length of the carapace is about 2 to 3. No overlap is seen although the free margin of the left valve is distinctly rabbetted, probably to accommodate the edge of the right valve.

Discussion.—Although similar in most respects to *E. rhomboidea* Jones[25] from the Hamilton of New York, *E. rugatulus* is a little less rhomboidal in outline and the wrinkles are not as definitely longitudinal as in the original description and figure. Jones does not mention the small mesh found between the wrinkles in the new species, and it is a very easily seen characteristic.

Bell shale, Middle Devonian, Michigan.

Family CYTHERELLIDAE Sars

Genus CYTHERELLA Jones

CYTHERELLA QUAESITA Roth

Plate 39, figures 1, 2

Roth, R., *1929*, Jour Paleontology, vol. 3, p. 367, pl. 38, fig. 27*a*, *b*, *c*.

Subrhomboidal. Maximum length 0.48–0.56 mm., measured a little ventrad of midway between the dorsum and venter. Maximum height 0.32 mm., measured through the anterior quarter. Maximum breadth is measured in the posterior quarter through the ridge.

Surface smooth except for a posterior, dorsal depression and crescentiform posterior ridge.

Dorsum straight with subequal cardinal angles. The venter is straight. The posterior is nearly square, but rounded. The anterior slopes to the venter where it is most convex. The ends are subequal although the posterior is slightly oblique.

Hingement cannot be determined because hinge structure is not exposed in any specimen. The ratio of the length of the hinge to the maxi-

[25] Jones, T. R., *Quart. Jour. of Sci.*, vol. 46, p. 10, pl. 2, fig. 102, 1890.

mum length of the carapace is about 3 to 5. The right valve overlaps the left, especially at the venter and the ends. The left valve overlaps the right along the dorsum.

Discussion.—This specimen fits the generic description of *Cytherella* in most respects. There appears to be a faint depressed spot in the center, but this is not absolutely certain, because of the nature of preservation. This species rather closely resembles *C. calcar* Harlton,[26] a Pennsylvanian form. The shape is similar, but *C. quaesita* Roth can be easily distinguished by its posterior crescentic ridge and depression.

Bell shale, Middle Devonian, Michigan.

[26] Harlton, Bruce, *Tex. Univ. Bull.* 2901 p. 161, 1929.

BIBLIOGRAPHY OF THE FORAMINIFERA FOR THE YEAR 1931

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FOREWORD

The steady increase of scientific papers dealing entirely or partially with fossil or recent foraminifera makes it desirable henceforth to issue each year a bibliographic list of all the publications that have appeared in print during the preceding year.

In order to make such an annual bibliography as complete as possible the writer welcomes the coöperation of fellow-workers. They can assist greatly by sending to him the exact and full titles of their papers (with place and date of publication, name of periodical, original pagination, number of plates and figures in text), or by forwarding a reprint or copy of their publications. It may be mentioned that the papers on foraminifera reaching the writer will be reviewed in *Paleontologisches Zentralblatt*, edited by Prof. O. H. Schindewolf, and will also be used for compilation of an annual index to new genera and species of foraminifera.

Very much appreciated and needed are communications regarding papers and articles on foraminifera which appear in publications of local scientific societies and institutions, and are, therefore, not likely to be found in all libraries abroad.

The present bibliography deals only with papers published during the year 1931. For all publications previous to the year 1911 reference is made to K. Beutler's *Palaeontologisch-stratigraphische und zoologisch-systematische Literatur über marine Foraminiferen fossil und rezent bis Ende 1910*, (Munich, 1911, 144 pp., including about 3,900 titles), while a more recent list of publications by A. D. Liebus, *Bibliographia foraminiferum recentium et fossilium (1911–1930)* (Fossilium Catalogus, I., part 49, Berlin 1931, 36 pp., including about 725 titles) comprises the period between 1911 and 1930, inclusive. As the latter shows only about 60 per cent of the published literature during this period, a final re-edition or at least a completing appendix should be issued.

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PARKER, FRANCES L., see Cushman and Parker.

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———, see Chapman and Parr.

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———, see Dunbar and Skinner.

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SPIELMANN, P. E., see Hackford and Lawson.

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137. ——— and RICE, ELMER M. Notes on the Saratoga chalk: *Jour. Paleontology*, vol. 5, pp. 316–328.

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VAN DER VLERK, I. M., see Leupold and Van der Vlerk.

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WEYMOUTH, A. ALLEN, see Barbat and Weymouth.

140. WILSON, ROBERT R., Miocene shales of the Adelaide quadrangle, San Luis Obispo County, California: *Micropaleontology Bull., Stanford Univ.*, vol. 2, no. 5, pp. 102–104.

141. WOODRING, W. P., Upper Eocene orbitoidal foraminifera from the Santa Ynez Range, California (abstract): *Geol. Soc. America, Bull.*, vol. 42, p. 370.

142. ———, Distribution and age of the marine Tertiary deposits of the Colorado deserts: *Carnegie Inst. Washington, Pub.* 418, *Contrib. to Paleontology*, pp. 1–25.

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INDEX TO GENERA AND SPECIES OF FORAMINIFERA ERECTED DURING THE YEAR 1931

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FOREWORD

Since the publication of Ch. D. Sherborn's *Index to the Genera and Species of the Foraminifera* (Washington 1893 and 1896), apparently no attempt has been made to carry on such an important and valuable work up to the present time. The present list comprises the new names which appeared in the literature for the year 1931.

During the year 1931 eleven new genera and 194 new species and varieties of foraminifera were erected. There are possibly some names omitted or overlooked, and the writer will be grateful for communicating omitted names in order to list them in an appendix to the forthcoming index for the year 1932. The writer has consulted all the publications given in his "Bibliography on Foraminifera for the year 1931," with the exception of the following, which he had no opportunity to see:

CHAPMAN, F., A report on samples obtained by boring into Michaelmas Reef . . . : *Rep. Great Barrier Reef Comm.*, vol. 3, p. 32 ff.

HANZAWA S., Notes on raised coral reefs . . . in Taiwan (Formosa): *Recent Oceanogr. Works in Japan*, vol. 3, no. 2, p. 37. ff.

and RENNGARTEN, V. Les Orbitoides et les Nummulites du versant sud du Caucase: *Trans. Geol. Prosp. Serv. U.S.S.R.*, vol. 24.

Under each genus or species listed, reference is made by number (in boldface type) to the preceding bibliography of papers treating on foraminifera. This method of citation has slight inconvenience, perhaps, but avoids the necessity of numerous repetitions of the same references and thus conserves space.

NEW GENERA AND SPECIES

Alveolina maiellana Silvestri, **127,** 72, pl. 1, f. 3–8. Cretaceous, Italy.

Amphilepidina, see *Lepidocyclina*.

Angulogerina fijiensis Cushman, **33,** 31, pl. 4, f. 11. Upper Tertiary, Fiji.

Anomalina barrowi Cushman and Ellisor, **43,** 57, pl. 7, f. 10. Upper Eocene, Texas.

——— *jacksonensis* (Cushman and Applin 1926) var. *limbosa* Cushman and Ellisor, **43,** 58, pl. 7, f. 11. Upper Eocene, Texas.

——— *coronata* Parker and Jones 1857 var. *crassa* Cushman, **40,** 105, pl. 19, f. 1, 2. Recent, Atlantic.

——— *flintii* Cushman (for *Anomalina ammonoides* Flint 1897 (1899), not Reus 1845, Rep. U. S. Nat. Mus. for 1897, Washington, 1899, p. 335, pl. 78, f. 4), **40,** 108, pl. 18, f. 5. Recent, Atlantic.

Articulina sp. Cole, **27,** 22, pl. 7, f. 9. Pliocene, Florida.

Assilina formosensis Hanzawa, **76,** 193, pl. 29, f. 1–9. Eocene, Taiwan, Japan.

Astacolus dissonus Plummer (for *Cristellaria reniformis* Carsey 1926), **113,** 145, pl. 11, f. 17, 18; pl. 15, f. 2–7. Upper Cretaceous, Texas.

——— *taylorensis* Plummer (for *Cristellaria gibba* Carsey 1926), **113,** 143, pl. 11, f. 16; pl. 15, f. 8–11. Upper Cretaceous, Texas.

Baggina totomiensis Makiyama, **103,** 52, text f. 4. Pliocene, Japan.

Bathysiphon sp. (?) Cushman and Laiming, **45,** 92, pl. 9, f. 1. Miocene, California.

Bolivina colemani Galloway and Morrey, **64** 349, pl. 40, f. 2. Upper Cretaceous, Mexico.

——— *monilifera* Galloway and Morrey, **64** 349, pl. 40, f. 3. Upper Cretaceous, Mexico.

——— *pondi* Cushman, **41,** 50, pl. 8, f. 5. Upper Cretaceous, Tennessee.

——— *sp.* (?) Cushman, **41,** 50, pl. 8, f. 7. Upper Cretaceous, Tennessee.

——— *tenuis* Marsson 1878 var. *selmaensis* Cushman, **41,** 49, pl. 8, f. 6. Upper Cretaceous, Tennessee.

Bulimina callahani Galloway and Morrey, **64,** 350, pl. 40, f. 6. Upper Cretaceous, Mexico.
——— *inflata* Seguenza 1862 var. *alligata* Cushman and Laiming, **45,** 107, pl. 11, f. 17. Miocene, California.
——— *rinconensis* Cushman and Laiming, **45,** 107, pl. 11, f. 18. Miocene, California.
——— *sp.* Cole, **27,** 39, pl. 5, f. 13. Pliocene, Florida.
——— *tabascoensis* Galloway and Morrey, **64,** 352, pl. 40, f. 11. Upper Cretaceous, Mexico.
Buliminella carseyae Plummer (for *Bulimina compressa* Carsey 1926), **113,** 179, pl. 8, f. 9. Upper Cretaceous, Texas.
——— *parallela* Cushman and Parker, **46,** 13, pl. 3, f. 15. Recent, Atlantic Coast, South America.
Carpenteria hassleri Cushman, **40,** 141, pl. 26, f. 2–5. Recent, Atlantic.
——— *sp. indet.* Hanzawa, **74,** 155, pl. 25, f. 18. Neogene, Japan.
Cassidulina cretacea Cushman, **41,** 56, pl. 10, f. 3. Upper Cretaceous, Tennessee.
Cassidulinoides chapmani Parr, **111,** f. a–c in text. Miocene, Victoria, Australia.
Cibicides americanus (Cushman 1918) var. *crassiseptus* Cushman and Laiming, **45,** 119, pl. 14, f. 7. Miocene, California.
——— *cognatus* Galloway and Morrey, **64,** 345, pl. 39, f. 5. Upper Cretaceous, Tabasco, Mexico.
——— *pseudoungeriana* (Cushman 1922) var. *10* (for *Truncatulina tenera* Flint 1897 (1899); not Brady 1884, Rep. U. S. Nat. Mus. for 1897, Washington 1899, p. 334, pl. 77, f. 4 (?)), **40,** 125, pl. 23, f. 1, 2. Recent, Atlantic.
——— *spiropunctatus* Galloway and Morrey, **64,** 346, pl. 39, f. 7. Upper Cretaceous, Tabasco, Mexico.
——— *yazooensis* Cushman, **35,** 59, pl. 7, f. 12 Upper Eocene, Mississippi.
Clavulina insignis Plummer (for *C. triquetra* Martinotti 1925, and *Tritaxia tricarinata* Carsey 1926), **113,** 138, pl. 8, f. 1–4. Upper Cretaceous, Texas.
——— *patens* Cushman and Laiming, **45,** 96, pl. 10, f. 2. Miocene, California.
Cyclammina cancellata Brady 1876 var. *obesa* Cushman and Laiming, **45,** 94, pl. 9, f. 10. Miocene, California.
Dentalina crinita Plummer (for *Nodosaria consobrina* Carsey 1926), **113,** 154, pl. 11, f. 12, 13. Upper Cretaceous, Texas.
——— *mutsui* Hada, **71,** 97, f. 50 in text. Recent, Mutsu Bay, Japan.
——— *quadrulata* Cushman and Laiming, in: Cushman and Parker, **47,** 3, pl. 1, f. 9–11. Miocene, California.
——— *sp. indet.* Hanzawa, **75,** 170, pl. 28, f. 17. Miocene, Japan.
Discorbis bertheloti (d'Orbigny 1839) var. *floridensis* Cushman, **40,** 17, pl. 3, f. 3–5. Recent, Atlantic.
(Note: This variety has already been published by Cushman and Jarvis in *Jour. Paleontology*, vol. 4, p. 364, pl. 33, f. 13, 1930, from the Miocene of Jamaica.
——— *gladysae* Cole, **27,** 47, pl. 3, f. 9, 10. Pliocene and Pleistocene, Florida.
——— *globularis* (d'Orbigny 1826) var. *anglica* Cushman (for *Discorbina irregularis* Heron-Allen and Earland 1913, not Rhumbler 1903, Proc. Irish Acad., vol. 31, pt. 64, p. 120, pl. 10, f. 2–4). **40,** 23, pl. 4, f. 10. Recent, Atlantic.
——— *hemisphaerica* Cushman, **35,** 59, pl. 7, f. 14. Upper Eocene, Mississippi.
——— *tabascoensis* Galloway and Morrey, **64,** 344, pl. 39, f. 3. Upper Cretaceous, Tabasco, Mexico.
Dorothia nov. gen. Plummer, **113,** 130, (Genotype: *D. Bulletta* Carsey 1926). Upper Cretaceous, Texas.
Ellipsodimorphina elongata Storm, **134,** 27, f. on plate. Upper Cretaceous, Bohemia.
Ellipsolagena fijiensis Cushman, **33,** 32, pl. 4, f. 6. Upper Tertiary, Fiji.
Ellipsonodosaria sp. (?) Cushman, **41,** 52, pl. 8, f. 11–13. Upper Cretaceous, Tennessee.
Elphidium alvarezianum Cushman 1930 var. *serrulatum* Cushman and Parker, **46,** 12, pl. 2, f. 9. Recent, Atlantic Coast, South America.
——— *australis* Cushman and Parker, **46,** 12, pl. 2, f. 8. Recent, Atlantic Coast, South America.
——— *eocenicum* Cushman and Ellisor, **43,** 53, pl. 7, f. 6. Upper Eocene, Texas.
——— *gunteri* Cole, **27,** 34, pl. 4, f. 9, 10. Pliocene, Florida.

——— ——— var. *galvestonensis* Kornfeld, **89,** 87, pl. 15, f. 1–3. Recent, Gulf Coast, Texas.
——— *incertum* (Williamson 1858) var. *mexicanum* Kornfeld, **89,** 89, pl. 16, f. 1, 2. Recent, Gulf Coast, Texas.
Endothyra gallowayi A. O. Thomas, **135,** 40, pl. 7, f. 1–9. Late Devonian, Iowa.
Eouvigerina hispida Cushman, **41,** 45, pl. 7, f. 12, 13. Upper Cretaceous, Tennessee.
Eponides jamaicensis Cushman and Jarvis, **44,** 77, pl. 10, f. 4. Eocene, Jamaica.
——— *vicksburgensis* Cushman and Ellisor, **43,** 56, pl. 7, f. 8. Lower Oligocene, Texas.
Flabellammina saratogaensis Cushman, **42,** 298, pl. 34, f. 1. Upper Cretaceous, Arkansas.
Flosculina agrigentina Sorrentino, **131,** 218, text f. Eocene, Italy.
Frondicularia cuspidata Cushman, **41,** 36, pl. 5, f. 4, 5. Upper Cretaceous, Tennessee.
——— *glabrans* Cushman, **41,** 34, pl. 4, f. 12. Upper Cretaceous, Tennessee.
Fusiella primaeva Skinner, **129,** 255, pl. 30, f. 7–9, 11. Pennsylvanian, Texas.
"*Fusilina*" *forakerensis* Skinner, **130,** 17, pl. 4, f. 1–4. Permo-Pennsylvanian, Oklahoma.
——— *turki* Skinner, **130,** 18, pl. 3, f. 7–9. Permo-Pennsylvania, Oklahoma.
Fusilina leei Skinner, **129,** 257, pl. 30, f. 4, 6. Pennsylvanian, Oklahoma.
——— *llanoensis* N. L. Thomas, **136,** 31, pl. 1, f. 1–7. Pennsylvanian, Texas.
Gaudryina gracilis Cushman and Laiming, **45,** 95, pl. 10, f. 1. Miocene, California.
Gaudryinella nov. gen. Plummer, **114,** 341. (Holotype: *G. delrioensis* Plummer 1931.)
——— *delrioensis* Plummer (for *Textularia* spec. Margaret Carpenter 1925), **114,** 341, f. 1*a*, *b* in text. Upper Cretaceous, Texas.
Glandulina ozawai Cushman (for *G. reussi* Cushman and Ozawa 1930), **38,** 83. Oligocene, Germany.
Globobulimina sobrina Galloway and Morrey, **64,** 352, pl. 40, f. 12. Upper Cretaceous, Tabasco, Mexico.
Globorotalia delrioensis Plummer, **113,** 199, pl. 13, f. 2. Upper Cretaceous, Texas.
Globotruncana fornicata Plummer, **113,** 198, pl. 13, f. 4–6. Upper Cretaceous, Texas.
Gümbelina spinifera Cushman, **41,** 43, pl. 7, f. 8. Upper Cretaceous, Tennessee.
Guttulina hughesi Cushman and Laiming, **45,** 102, pl. 11, f. 5. Miocene, California.
Haplophragmoides canariensis (d'Orbigny 1839) var. *mexicana* Kornfeld, **89,** 83, pl. 13, f. 4. Recent, Gulf Coast, Louisiana.
Haplostiche jamaicensis Cushman and Jarvis, **44,** 75, pl. 10, f. 1. Eocene, Jamaica.
Hastigerinella alexanderi Cushman, **39,** 87, pl. 11, f. 6–9. Cretaceous, Austin chalk, Texas.
——— *moremani* Cushman, **39,** 86, pl. 11, f. 1–3. Upper Cretaceous, Eagleford, Texas.
——— *watersi* Cushman, **39,** 86, pl. 11, f. 4, 5. Cretaceous, Austin chalk, Texas.
Hemicristellaria silicula Plummer (for *Vaginulina* (*?*) *trilobata* (*?*) Cushman 1930), **113,** 148, pl. 10, f. 8, 9. Upper Cretaceous, Texas.
Heronallenia nov. gen. Chapman and Parr, **23,** 236. (Genotype: *Discorbina wilsoni* Heron-Allen et Earland 1922; Recent, Antarctic.)
Hofkerina nov. gen. Chapman and Parr, **23,** 237. (Genotype: *Pulvinulina semiornata* Howchin 1889, Oligocene, Victoria, Australia.)
Hyperammina sp. (*?*), Cushman and Laiming, **45,** 92, pl. 9, f. 2. Miocene, California.
Lagena basi-striatula Cushman, **33,** 27, pl. 4, f. 5. Upper Tertiary, Fiji.
——— *collomi* de Lapparent (for "embryons de *Lagena*," de Lapparent 1925), **96,** 222–223. Cretaceous, Europe.
——— *schwageriana* Cushman (for *Lagena formosa* Schwager 1866, partim), **33,** 26, pl. 4, f. 2. Upper Tertiary, Fiji.
——— *spino-alata* Cushman, **33,** 27, pl. 4, f. 4. Upper Tertiary, Fiji.
——— *spiro-striolata* Cushman (for *Lagena lineata* Sidebottom 1912, partim.), **33,** 27, pl. 4, f. 3. Upper Tertiary, Fiji.
Lamarckina atlantica Cushman, **40,** 35, pl. 7, f. 7. Recent, Atlantic.
Lenticulina sp. Cole, **27,** 27, pl. 6, f. 1. Pliocene, Florida.
——— *totomiensis* Makiyama, **103,** 51, pl. 2, f. 12, 14, 15. Pliocene, Japan.
Lepidocyclina deforma Berry, **15,** 162, pl. 5, f. 1–5. Eocene, Peru.
——— (*Amphilepidina*) *laevigata* Hanzawa, **75,** 166, pl. 27, f. 16; pl. 28, f. 1. Miocene, Japan.

——— (———) *nipponica* Hanzawa, **74,** 151, pl. 24, f. 1–7, 11; pl. 25, f. 1–5; pl. 26, f. 1–3, 5. Neogene, Japan.
——— (———) ——— Hanzawa var. *izuensis* Hanzawa, **75,** 163, pl. 27, f. 5–8. Miocene, Japan.
——— (———) *polygonalis* Hanzawa, **75,** 164, pl. 28, f. 8, 9. Miocene, Japan.
——— (———) *scabra* Hanzawa, **75,** 165, pl. 27, f. 14, 15; pl. 28, f. 2–4. Miocene, Japan.
——— *triplana* Berry, **15,** 163, pl. 5, f. 6–8. Eocene, Peru.
Linderina buranensis Nuttall and Brighton, **19,** 58, pl. 4, f. 8–14; f. 3 in text. Eocene, Somaliland.
Loxostomum plaitum (Carsey 1926) var. *limbosum* Cushman, **41,** 52, pl. 8, f. 10. Upper Cretaceous, Tennessee.
Massilina pratti Cushman and Ellisor (for *Massilina sp.* (?) Cushman and Applin 1926), **43,** 53, pl. 7, f. 4. Upper Eocene, Texas.
Miogypsina kotoi Hanzawa, **74,** 154, pl. 25, f. 14–18. Neogene, Japan.
——— *ozawai* Hanzawa, **74,** 155, pl. 24, f. 12; pl. 25, f. 10–13; pl. 26, f. 3. Neogene, Japan.
——— *yabei* Hanzawa, **74,** 154, pl. 25, f. 6–9; pl. 26, f. 5. Neogene, Japan.
Nodogenerina advena Cushman and Laiming, **45,** 106, pl. 11, f. 19. Miocene, California.
Nodosarella pacifica Cushman, **33,** 31, pl. 4, f. 12, 13. Upper Tertiary, Fiji.
——— *sp.* (?) Cushman, **34,** 42, pl. 6, f. 4. Cretaceous, Antiqua, B.W.I.
Nodosaria parexilis Cushman and K. C. Stewart 1930 var. *sentifera* Cushman and Parker, **47,** 6, pl. 1, f. 16. Miocene, California.
——— *pozoensis* Berry, **12,** text f. 1. Eocene, Peru.
Nonion depressula (Walker and Jacob 1798) var. *matagordana* Kornfeld, **89,** 87, pl. 13, f. 2. Recent, Gulf Coast, Texas.
——— *galeata* Cushman, **33,** 28, pl. 4, f. 7. Upper Tertiary, Fiji.
——— *laevis* (d'Orbigny 1826) var. *marginatum* Cushman and Ellisor, **43, 52,** pl. 7, f. 5. Upper Eocene Texas.
Nonionella clavata Cushman, **33,** 30, pl. 4, f. 9. Upper Tertiary, Fiji.
——— *cretacea* Cushman, **41,** 42, pl. 7, f. 2. Upper Cretaceous, Tennessee.
——— *hantkeni* (Cushman and Applin 1926) var. *spissa* Cushman, **35,** 58, pl. 7, f. 13. Upper Eocene, South Carolina.
——— *limbato-striata* Cushman, **33,** 30, pl. 4, f. 8. Upper Tertiary, Fiji.
——— *pseudo-auris* Cole, **27,** 32, pl. 5, f. 4, 5. Pliocene, Florida.
——— *pulchella* Hada, **71,** 120, text. f. 79. Recent, Mutsu Bay, Japan.
——— *robusta* Plummer (for *Nonionina scapha* Carsey 1926), **113,** 175, pl. 14, f. 12. Upper Cretaceous, Texas.
Nouria tenuis Hada, **71,** 94, text f. 47. Recent, Mutsu Bay, Japan.
——— *textulariformis* Hada, **71,** 93, text f. 46. Recent, Mutsu Bay, Japan.
Nummulites hormoensis Nuttall and Brighton, **19,** 53, pl. 3, f. 1–8. Eocene, Somaliland.
——— *somaliensis* Nuttall and Brighton, **19,** 52, pl. 2, f. 5–14, f. 1 in text. Eocene, Somaliland.
Operculina sp. indet. Hanzawa, **74,** 156, pl. 25, f. 22. Neogene, Japan.
Ozawaia nov. gen. Cushman, **37,** 80. (Holotype: *O. tongaensis* Cushman 1931).
——— *tongaensis* Cushman (for *Polystomella crispa* Millett 1904), **37,** 80, pl. 10, f. 7–10. Recent, Tonga Islands, South Pacific.
Parafusulina nov. gen. Dunbar and Skinner, **60,** 251. (Holotype: *P. wordensis* Dunbar and Skinner 1931.)
——— *wordensis* Dunbar and Skinner, **60,** 261, pl. 2, f. 1–4. Permian, West Texas.
Parrina nov. gen. Cushman, **32,** 20. (Genotype: *P. inflata* (Brady 1884; for *Nubecularia inflata* Brady 1884.) Recent.
Patellina sp. (?) Cushman, **41,** 52, pl. 8, f. 14. Upper Cretaceous, Tennessee.
Planularia markleyana Church, **26,** 210, pl. B, f. 1, 10. Eocene, California.
Planulina caribaea Cushman, **40,** 112, pl. 20, f. 1. Recent, Atlantic.
Plectofrondicularia jenkinsi Church, **26,** 202, pl. A, f. 4, 5, 7, 8 and 9. Eocene, California.
——— *mansfieldi* Cushman and Ponton, **49,** 60, pl. 8, f. 1. Miocene, Florida.
——— *miocenica* Cushman 1926 var. *directa* Cushman and Laiming, **45,** 105, pl. 11, f. 12. Miocene, California.
——— *sp.* (?) Cushman and Laiming, **45,** 105, pl. 11, f. 13. Miocene, California.

——— *sp.* Galloway and Morrey, **64,** 349, pl. 40, f. 4. Upper Cretaceous, Tabasco, Mexico.

——— *totomiensis* Makiyama, **103,** 51, pl. 2, f. 16. Pliocene, Japan.

Polydiexodina nov. gen. Dunbar and Skinner, **60,** 263. (Holotype: *P. capitanensis* Dunbar and Skinner 1931.)

——— *capitanensis* Dunbar and Skinner, **60,** 264, pl. 3, f. 7–11. Permian, West Texas.

——— *shumardi* Dunbar and Skinner, **60,** 267, pl. 3, f. 1–6. Permian, West Texas.

Proteonina crassa Hada, **71,** 54, text f. 5. Recent, Mutsu Bay, Japan.

Pseudofusulina nov. gen. Dunbar and Skinner, **60,** 252. (Holotype: *P. hueconensis* Dunbar and Skinner 1931.)

——— *hueconensis* Dunbar and Skinner, **60,** 257, pl. 1, f. 3–6*a*. Permian, and uppermost Pennsylvanian, West Texas.

Pseudoglandulina sp. Plummer (for *Nodosaria laevigata* Carsey 1926), **113,** 158, pl. 10, f. 16, 17. Upper Cretaceous, Texas.

Pseudopolymorphina cuyleri Plummer, **113,** 173, pl. 9, f. 18–21. Upper Cretaceous, Texas.

Pseudouvigerina cretacea Cushman, **41,** 46, pl. 7, f. 14. Upper Cretaceous, Tennessee.

——— *sp.* (*?*) Cushman, **34,** 40, pl. 6, f. 1. Cretaceous, Antigua, B.W.I.

Pullenia lillisi Church, **26,** 208, pl. A, f. 10. Eocene, California.

——— *puentepiedraensis* Galloway and Morrey, **64,** 341, pl. 38, f. 11. Upper Cretaceous, Tabasco, Mexico.

Pulvinulinella parva Cushman and Laiming, **45,** 115, pl. 13, f. 5. Miocene, California.

——— *subperuviana* Cushman var. *minuta* Cushman and Laiming, **45,** 116, pl. 13, f. 6. Miocene, California.

Quinqueloculina jamaicensis Cushman and Jarvis, **44,** 76, pl. 10, f. 2, 3. Eocene, Jamaica.

——— *sp.* Cole, **27,** 22, pl. 1, f. 1. Pliocene, Florida.

——— *subquadra* Hada, **71,** 78, text f. 31. Recent, Mutsu Bay, Japan.

Reophax sp. (*?*) Cushman and Laiming, **45,** 92, pl. 9, f. 3. Miocene, California.

Robulus mayi Cushman and Parker, **47,** 2, pl. 1, f. 3–5. Miocene, California.

——— *pondi* Cushman, **41,** 25, pl. 2, f. 9 Upper Cretaceous, Tennessee.

——— *welchi* Church, **26,** 212, pl. C, f. 13, 14. Eocene, California.

Rotalia caloosahatcheensis Cole, **27,** 51, pl. 3, f. 1, 2. Pliocene, Florida.

——— *japonica* Hada, **71,** text f. 93. Recent, Mutsu Bay, Japan.

——— *puscatanensis* Galloway and Morrey, **64,** 342, pl. 38, f. 13. Upper Cretaceous, Tabasco, Mexico.

Sagrinnodosaria nov. gen. Jedlitschka (for *Dentalina verneuilli* d'Orb. 1846), **86,** 125, Fossil and Recent.

Schubertella gallowayi Skinner, **129,** 256, pl. 30, f. 1, 5. Pennsylvanian, Oklahoma.

Sigmomorpha ozawai Hada, **71,** 115, text f. 73 and 74. Recent, Mutsu Bay, Japan.

Sigmomorphina reedi Cushman and Laiming, **45,** 103, pl. 11, f. 6, 7. Miocene, California.

Siphogenerina digitalis Galloway and Morrey, (for *S. striata* (Schwager 1866) var. *curta* Cushman 1926, partim), **64,** 353, pl. 40, f. 14.

——— *mayi* Cushman and Parker, **47,** 10. pl. 2, f. 7. Miocene, California.

Siphonodosaria fijiensis Cushman, **33,** 30, pl 4, f. 10. Upper Tertiary, Fiji.

Spirillina vivipara Ehrenberg 1841 var. *densepunctata* Cushman, **40,** 4, pl. 1, f. 5. Recent, Atlantic.

(*Spiroloculina costata*) Hada, **71,** 84, text f. 37. Recent, Mutsu Bay. The name of this species is preoccupied by Terquem 1882. *Spiroloculina hadai* nomen novum is herewith proposed.

Spiroloculina cushmani Hada, **71,** 83, text f. 36. Recent, Mutsu Bay, Japan.

——— *hadai* Thalmann, for *S. costata* Hada 1931 (not Terquem 1882) in: Hada, **71,** 84, text f. 37. Recent, Mutsu Bay, Japan.

Spiroplectammina parallela Cushman, **33,** 26, pl. 4, f. 1. Upper Tertiary, Fiji.

——— *typica* Lacroix, **95,** 14, text f. 9. Recent, Mediterranean.

Spiroplectoides papillata Cushman, **41,** 44, pl. 7, f. 10. Upper Cretaceous, Tennessee.

Textularia cuneata Hada, **71,** 71, text f. 24. Recent, Mutsu Bay, Japan.

——— *elegans* Lacroix, **95,** 15, text f. 11. Recent, Mediterranean.

——— *mississippiensis* Cushman 1922 var. *rhomboidea* Cushman and Ellisor, **43,** 51, pl. 7, f. 1. Upper Eocene, Texas.
——— *pseudorugosa* Lacroix, **95,** 11, text f. 3. Recent, Mediterranean.
——— *warreni* Cushman and Ellisor, **43,** 51, pl. 7, f. 2. Lower Oligocene, Texas.
Triloculina linneiana d'Orbigny 1839 var. *caloosahatcheensis* Cole (for *T. linneiana* Cushman 1918), **27,** 25, pl. 1, f. 4–6. Pliocene, Florida.
Triticites koschmanni Skinner, **130,** 20, pl. 3, f. 4–6. Permo-Pennsylvanian, Oklahoma.
——— *rothi* Skinner, **130,** 19, pl. 3, f. 1–3. Permo-Pennsylvanian, Oklahoma.
——— *tumidus* Skinner, **130,** 21, pl. 4, f. 5–7. Permo-Pennsylvanian, Oklahoma.
Trochammina inflata (Montagu) var. *mexicana* Kornfeld, **89,** 86, pl. 13, f. 5. Recent, Gulf Coast, Louisiana.
——— *parva* Cushman and Laiming, **45,** 97, pl. 10, f. 3. Miocene, California.
——— *teasi* Cushman and Ellisor, **43,** 52, pl. 7, f. 3. Upper Eocene, Texas.
Ungulatella nov. gen. Cushman, **37,** 81. (Holotype: *U. pacifica* Cushman, 1931. Recent.)
——— *pacifica* Cushman, **37,** 82, pl. 10, f. 11, 12. Recent, South Pacific.
Uvigerina vicksburgensis Cushman and Ellisor, **43,** 54, pl. 7, f. 7. Lower Oligocene, Texas.
Uvigerinella obesa Cushman 1926 var. *impolita* Cushman and Laiming, **45,** 111, pl. 12, f. 11. Miocene, California.
——— *sparsicostata* Cushman and Laiming, **45,** 112, pl. 12, f. 12. Miocene, California.
Vaginulina regina Plummer (for *Vaginulina simondsi* Moreman 1927 and *Vaginulina sp.* (*?*) Cushman 1930), **113,** 162, pl. 10, f. 22. Upper Cretaceous, Texas.
——— *sp.* (*?*). **41,** 34, pl. 4, f. 9, 10. Upper Cretaceous, Tennessee.
——— *stutzeri* Eichenberg, **61,** 5, text f. 2. Cretaceous, Lower Hauterivian, Germany.
Valvulineria asterigerinoides Plummer (for *Anomalina sp.* Carsey 1925), **113,** 190, pl. 14, f. 6. Upper Cretaceous, Texas.
——— *casitasensis* Cushman and Laiming, **45,** 113, pl. 13, f. 1. Miocene, California.
——— *texana* Cushman and Ellisor, **43,** 56, pl. 7, f. 9. Upper Eocene, Texas.
Ventilabrella carseyae Plummer (for *Textularia globulosa* Carsey 1926), **113,** 178, pl. 9, f. 7–9. Upper Cretaceous, Texas.
Vertebralina jamaicensis Cushman and Jarvis, **44,** 77, pl. 10, f. 5, 6. Eocene, Jamaica.
Virgulina miocenica Cushman and Ponton, **48,** 32, pl. 4, f. 14–16. Miocene, Florida.
Wedekindia henbesti Skinner, **129,** 259, pl. 30, f. 2, 3. Pennsylvanian, Oklahoma.

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